SNAKE RIVER BIRDS OF PREY RESEARCH PROJECT

ANNUAL REPORT

1984

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
BOISE DISTRICT
IDAHO

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

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NOT FOR PUBLICATION

The data presented herein are preliminary and may be inconclusive. Permission to publish or cite any of these materials is therefore withheld pending specific authorization of the Boise District, BLM, and the specific Principal Investigator.

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PREFACE

This report summarizes activities of the Snake River Birds of Prey Research Program during calendar year 1984. As recommended by the 1982 Birds of Prey Review Committee, most work was directed towards technology transfer; however, significant effort was dedicated to initiating new cooperative research. Fifteen scientific articles were published and/or accepted for publication in 1984, and Birds of Prey staff members made 14 technical presentations at meetings. In addition, 3 cooperative research efforts were conducted this year, 2 with Pacific Power and Light Company and 1 with Idaho Power Company.

Basic monitoring of the vegetation and certain prey and raptors continued in 1984. Work began in fall 1984 on developing a long-term monitoring plan for the Birds of Prey Area. Also, in the fall 1984 the contract with the University of Idaho expired; future prey and vegetation monitoring will be conducted by Bureau employees.

Other 1984 field activities included Dr. Carl Marti's continuing investigation of common barn-owl feeding ecology, Dr. Marc Bechard's study on red-tailed hawk nest defense, Dr. Marcia Wicklow-Howard's investigation of the association of mycorrhiza with desert shrubs, and a survey of western screech-owls nest box use, reproduction and food habits.

The 1982 Birds of Prey Review Committee recommended that efforts be initiated to obtain outside funding to support continued and future research. In 1984 the BLM entered into cooperative agreements with Idaho Power Company and Pacific Power and Light Company to conduct cooperative research efforts. The results of the 1984 field season of these studies are presented in this report.

ACKNOWLEDGMENTS

The Bureau of Land Management wishes to thank those agencies and individuals who assisted with the project. Appreciation is extended to the Idaho Department of Fish and Game and the U.S. Fish and Wildlife Service for special permits and assistance. Special thanks go to all other individuals who volunteered their services.

Special appreciation is extended to Mr. E. T. Evans for providing the area for the Melba field camp and other assistance. Terri Thomason deserves special thanks for typing the manuscripts.

COOPERATING AGENCIES AND INSTITUTIONS

Boise State University
Idaho Department of Fish and Game
Idaho Power Company
Oregon Department of Fish and Wildlife
Pacific Power and Light Company
University of Idaho
University of Montana
U.S. Fish and Wildlife Service
U.S. Forest Service
Vale District, Bureau of Land Management
Virginia Polytechnic Institute
Weber State College

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PART I

TECHNOLOGY TRANSFER

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*Reprints of most of these articles are available from the Birds of Prey Research Project, Boise District, BLM, 3948 Development Avenue, Boise, ID 83705.

1984 Birds of Prey Research Technical Presentations

1/17 - 18	Steenhof, K. Inventory and monitoring design considerations and data analysis review. 1-1/2 day session. Applied Wildlife Habitat Management 6000-10. Phoenix Training Center, Phoenix, Arizona.
1/84 - 5/84	Kochert, M.N., K. Steenhof, and M. Bechard. Idaho's birds of prey. (Biology 297/497). 2 credit hour class at Boise State University, Boise, Idaho.
2/3	Steenhof, K., and M.N. Kochert. Dispersal and migration of raptors from southwest Idaho. Idaho Chapter, The Wildlife Society, Boise, Idaho.
3/19	Kochert, M.N. Raptor habitat relations and management. Day session. Beginning professionals wildlife school. Phoenix Training Center, Phoenix, Arizona.
4/13	Steenhof, K. Data analysis review. Day session. Beginning professionals wildlife school. Phoenix Training Center, Phoenix, Arizona.
4/14	Yensen, D. Changes in vegetation patterns in the southwestern Idaho desert: a photo history. Idaho Academy of Sciences Meeting, Lewiston, Idaho.
7/12	Nydegger, N. Prey populations in relation to Artemisia vegetation types in southwestern Idaho. Wildland Shrub Symposium, Provo, Utah.
9/7	Steenhof, K. An overview of the Snake River Birds of Prey area. Australasian Raptor Association Meeting, Queensland, Australia.
9/26	Holthuijzen, A.M.A., and A.R. Ansell. The effects of construction activities at the Swan Falls hydroelectric power plant in southwestern Idaho on a breeding population of prairie falcons (Falco mexicanus). Ann. Edison Electric Institute Biologist' Workshop, Baltimore, Maryland.
10/6	Engel, K., et al. Communal roosting of common ravens in southwest Idaho. Idaho Ornithological Council, 12th Ann. Meeting, Pocatello, Idaho.
10/26	Holthuijzen, A.M.A., and J.C. Smith. Breeding biology and behavior of prairie falcons (Falco mexicanus) in southwestern Idaho. Ann. Meeting of the Raptor Research Foundation, Blacksburg, Virginia.
10/26	Holthuijzen, A.M.A., et al. The effects of industrial construction activities on breeding prairie falcons (Falco mexicanus) in southwestern Idaho. Ann. Meeting of the Raptor Research Foundation, Blacksburg, Virginia.

10/26 Kochert, M.N., et al. Utilization of a transmission line by nesting raptors and ravens. Ann. Meeting Raptor Research Foundation, Blacksburg, Virginia.

10/27 Engel, K., et al. Communal roosting of common ravens in southwest Idaho. Ann. Meeting Raptor Research Foundation, Blacksburg, Virginia.

12/12 - 13 Steenhof, K. Data analysis review. 2-day session. Applied Wildlife Habitat Management. Phoenix Training Center, Phoenix, Arizona.

PART II

PROGRESS REPORTS

TITLE: Densities and Reproductive Performance of Raptors and Ravens in the Snake River Birds of Prey Area and Comparison Area.

INVESTIGATORS: Michael N. Kochert, Research Leader.
John H. Doremus, Wildlife Biologist, Bruneau Resource Area.
Karen Steenhof, Associate Research Leader.
Randy M. Trujillo, Wildlife Biologist, Bruneau Resource Area.
Carla D. Schroer, SCA Volunteer.
William M. Iko, SCA Volunteer.
Deana M. Ramirez, Data Transcriber.

OBJECTIVES:

1. To determine reproductive performance of golden eagles at traditional sites.

2. To determine raptor and raven density in 3 segments of the canyon.

3. To determine wintering golden eagle densities in and near the study area.

ANNUAL SUMMARY

Research in 1984 focused on golden eagles (<u>Aquila chrysaetos</u>). Monitoring considered prairie falcons (<u>Falco mexicanus</u>), red-tailed hawks (<u>Buteo jamaicensis</u>), ferruginous hawks (<u>Buteo regalis</u>) and common ravens (<u>Corvus corax</u>) in the 3 traditional survey stretches. The number of wintering golden eagles counted on aerial transects increased from 1983. The number of occupied eagle territories in the Birds of Prey Study Area (BPSA) increased in 1984. Density surveys suggested an increase in the number of red-tailed hawk nesting pairs. Reproductive success of golden eagles decreased from 1983 to 1984.

METHODS

In January 1984, the 20 golden eagle aerial transects were flown between Meridian and Rupert, Idaho in a fixed-wing aircraft. Data were analyzed as in previous years.

Nesting raptors were located by ground and helicopter surveys in the BPSA and Comparison Area (Fig. 1). Golden eagles, prairie falcons, red-tailed hawks, ferruginous hawks and common ravens were counted on the north side of 3 sections of the canyon that covered approximately 80 km. The Dedication Site to Swan Falls, Balls Basin to Chattin Hill, and Pump to Waterfall stretches were surveyed on foot once each month in March, April, May, and June. Portions of the Dedication Site to Swan Falls section were surveyed by personnel from the Idaho Power Cooperative Study. Golden eagles in all of the Comparison Area and the remainder of the Birds of Prey Study Area were surveyed from a helicopter as part of the nesting study conducted by Pacific Power and Light Company (PP&L).

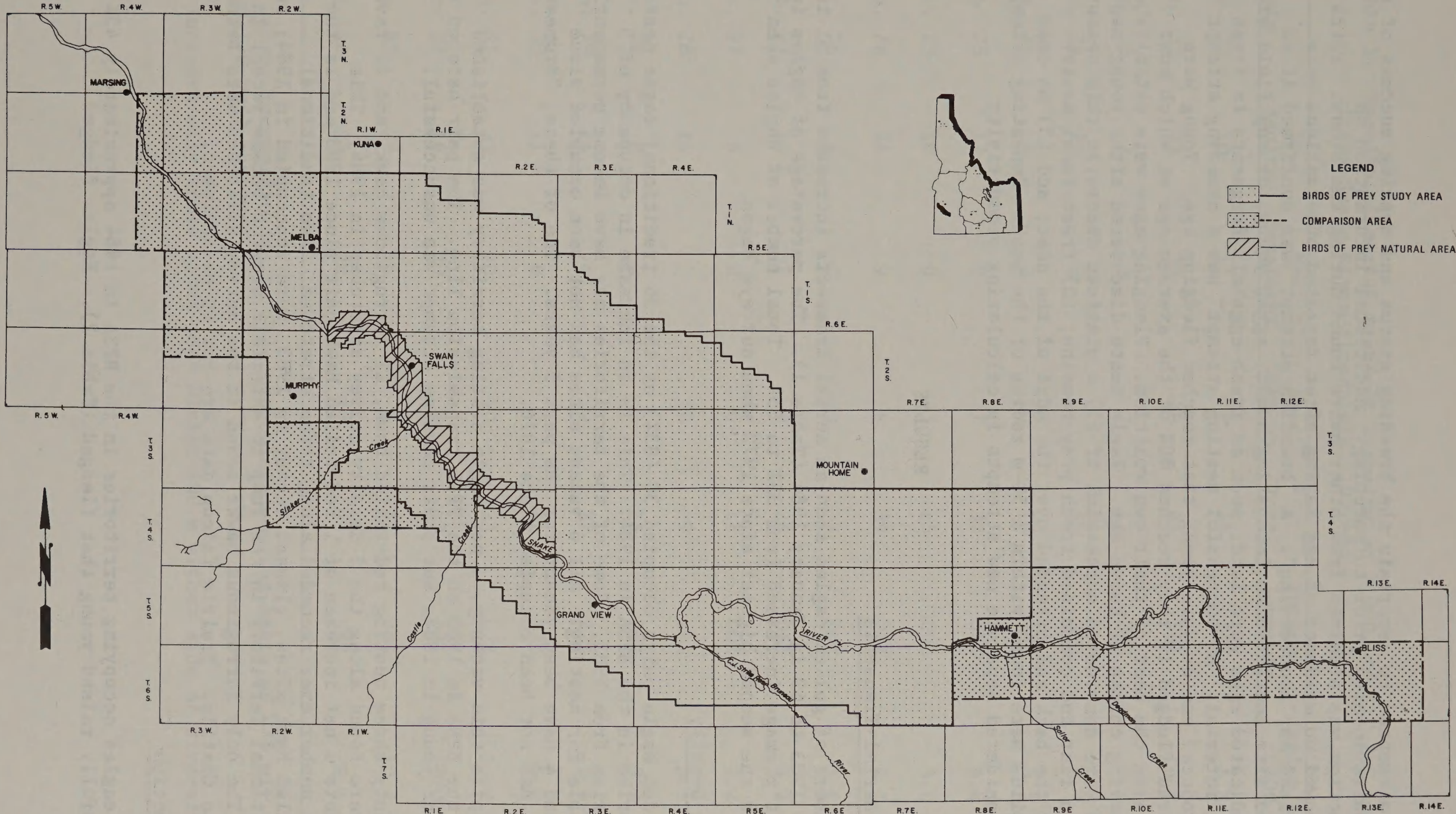

Fig. 1. LOCATION OF THE BIRDS OF PREY STUDY AREA (BPSA) AND COMPARISON AREA

We attempted to ascertain the breeding status and nesting success of all eagle pairs located prior to hatching. Additional information on reproduction was obtained from other pairs found during the study. Pairs that showed no evidence of egg laying after repeated observations were categorized as "nonbreeding". A "breeding attempt" was confirmed if an occupied site contained an incubating adult, eggs, young, or any field sign that indicated eggs were laid, such as fresh eggshell fragments in fresh nesting material. A "successful nesting attempt" was a breeding attempt that produced one or more young that reached fledging age. Young were considered fledged if they reached 80% of the average age at which most young leave the nest of their own volition. Fledging ages were established by observing chicks of known age. Eagle nests discovered after young had fledged were considered successful if (1) a platform decorated this season was worn flat and contained fresh prey remains; (2) fresh fecal matter covered the back and extended over the edge of the nest; and (3) no dead young birds were found within a 50-m radius of the nest. Renesting attempts were considered separate new attempts in calculating productivity.

RESULTS

Winter Aerial Transects

Numbers of golden eagles seen on aerial transects increased from 51 in January 1983 to 69 in January 1984 (Table 1). The percentage of eagles in subadult plumage increased from 35% to 55%. Total number of eagles seen in 1984 was the second highest since 1972 when surveys began.

Nesting Density

Golden eagle pairs occupied 30 (83%) of the 36 traditional eagle nesting territories in the BPSA in 1984. This is an increase in occupancy of 3 territories from 1983. Some of the territories may have become permanently unsuitable for nesting. All 6 vacant sites had not been occupied since 1982, and 4 have been vacant for the past 5 years. One of these, "Bruneau Flats", has not been occupied since 1976.

Despite this vacancy, a new eagle nesting territory was established within the BPNA in 1983 on the PP&L transmission line. The pair hatched at least one young in 1984, but their nesting attempt was unsuccessful.

Twenty-three nesting red-tailed hawk, 11 ferruginous hawk, and 47 raven pairs were found along the 3 density survey stretches in 1984. This represents a net increase of 1 red-tailed hawk pair since 1983 and is the highest number ever recorded along those stretches. Two traditional red-tailed hawk sites, classed vacant in 1983, were reoccupied in 1984; and 1 traditional territory in the Pump to Waterfall stretch became vacant in 1984. The only ferruginous hawks found in the survey stretches were between Balls to Chattin. Prairie falcon data are yet to be analysed.

Reproduction

Of eagles occupying territories in the BPSA in 1984 approximately 43% successfully raised young that fledged (Table 2). Eagles fledged

Table 1. Results of aerial transect sampling on 7,000 mi^2 (17,290 km^2) of the Snake River floodplain, 1972-84.

Date	No. Adults	No. Immatures	No. Unknown	Total	Percent Immature	Eagles/100 mi^2 /(100 km^2)**
Oct. 72	10	11	8	29	52%	5.8 (2.2)
Feb. 73	33	33	18	84	50%	16.8 (6.5)
Oct. 73	7	3	7	17	30%	3.4 (1.3)
Jan. 74	20	9	12	41	31%	8.2 (3.2)
Oct. 74	4	2	10	16	33%	3.2 (1.2)
Feb. 75	17	8	7	32	32%	6.4 (2.5)
Oct. 75	10	0	5	15	00%	3.0 (1.2)
Jan. 76	24	9	6	39	27%	8.1 (3.1)*
Oct. 76	4	0	3	7	00%	1.4 (0.5)
Feb. 77	16	1	9	26	06%	5.2 (2.0)
Oct. 77	5	0	6	11	00%	2.2 (0.8)
Jan. 78	16	3	10	29	16%	5.8 (2.2)
Oct. 78	8	2	6	16	20%	3.2 (1.2)
Jan. 79	14	4	9	27	22%	5.4 (2.1)
Jan. 80	11	8	2	21	42%	4.2 (1.6)
Jan. 81	23	20	10	53	47%	10.2 (4.0)
Jan. 82	14	20	9	43	59%	8.0 (3.1)
Jan. 83	28	15	8	51	35%	10.2 (3.9)
Jan. 84	23	28	18	69	55%	12.4 (4.8)

* Survey incomplete due to fog: calculated on the basis of 475 mi^2 (1170 km^2) surveyed.

** Includes only those birds seen within 400 m either side of aircraft.

Table 2. Reproductive performance of golden eagles and ravens in the BPSA and Comparison Area, 1984.

Species	% Pairs Successful	Clutch Size	Brood Size at Hatching	% of Attempts Successful		Number Fledged Per Successful Attempt	Number Fledged Per Pair[2]
				Standard[1]	Mayfield		
Golden eagle-BPSA only							
x	42.8			67%	59%	1.54	0.66
95% c.i.		--	--	--	39-91	1.25-1.82	
n				(12)	(18)	(15)	
Golden eagle-BPSA and Comparison Area							
x	48.1			73%	69%	1.45	0.70
95% c.i.		--	--	--	41-93	1.35-1.78	
n				(16)	(28)	(30)	
Common raven-BPSA only							
x	--	4.33	3.60	100%	88%	3.92	--
95% c.i.	--	--	--	--	67-114	--	--
n	--	(3)	(5)	(4)	(22)		

1 based only on pairs found during incubation [see Steenhof and Kochert (1982) for explanation].
2 calculated by multiplying percent pairs successful and number fledged per successful attempt.

approximately 0.66 young per pair. This represents a 33% decrease from 1983 but is similar to the 1977 production level. No pairs within the BPSA fledged 3 young in 1984. By including pairs outside the BPSA, overall estimates of percent pairs and attempts successful and young fledged per pair were slightly higher compared to just the BPSA. However, number fledged per successful attempt was lower (Table 2). Estimates of percent success based on the Mayfield model (Mayfield 1961) were similar to those based only on pairs found during incubation (Table 2).

Mean clutch size at 3 common raven nests was 4.33 eggs, and average brood size at hatching was 3.50 (n=5). Approximately 88% of the nesting attempts were successful, and an average of 3.92 chicks fledged from each successful nest (Table 2). Mean number of young fledged per sample pair was not calculated because data were lacking on percent pairs breeding; however, number of young fledged per attempt (3.44) was the highest ever recorded.

Banding and Marking

During 1984, 269 raptors and ravens were banded with aluminum U.S. Fish and Wildlife Service bands. This total included 8 golden eagles, 68 prairie falcons, 6 red-tailed hawks, 18 ferruginous hawks, 133 common ravens, 2 American kestrels (Falco sparverius), 19 western screech-owls (Otus kennicottii), 1 long-eared owl (Asio otus), and 2 Swainson's hawks (Buteo swainsoni) banded as nestlings in and near the Snake River Birds of Prey Area. More than 50% of the ravens were banded on the PP&L Transmission line as part of the roosting study. All ravens but 1 received colored wing markers and leg bands (see PP&L roosting annual report). Ten western screech-owls of unknown age were banded at nest boxes and winter roosts within the Birds of Prey Area, and 2 great horned owls (Bubo virginianus) were banded in central Idaho.

We received band recovery information on 2 golden eagles, 1 red-tailed hawk, 5 ravens, 2 ferruginous hawks and 9 western screech-owls. The eagles were 1.5 and 4 years old and were found in southern Idaho within 100 km of their marking locations. One of the eagles was electrocuted, and cause of death could not be determined for the other bird. One of the ferruginous hawks was 4.5 years old when it was recovered in the state of Chihuahua, Mexico during the winter, and the other was nearly 2 years old when it was found in the Birds of Prey Area only 2.9 km from its natal nest. All but one of the raven recoveries were postfledging mortalities near their nests. One raven was found 5 months after it fledged near Owyhee, Nevada. All screech-owls were captured at the nest boxes.

In 1984, 83 sightings of marked birds were recorded. One sighting was of a red-tailed hawk that was trapped and wing-marked as an adult in 1975 and has been seen on the same territory for 10 consecutive nesting seasons. A golden eagle, sighted wearing a backpack radio package, has been on the same territory since 1975 when it first arrived as a breeding bird. A wing-marked golden eagle that was nearly 4 years old was sighted in February. The remainder of the wing-marker sightings, except 1, were of post-fledged ravens in the study area. The exception was a young raven less than 6 months old sighted near Atomic City, in eastern Idaho.

LITERATURE CITED

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Steenhof, K., and M. N. Kochert. 1982. An evaluation of methods used to estimate raptor nesting success. J. Wildl. Manage. 46:885-893.

TITLE:	Abundance and Demography of Prey Populations in the Snake River Birds of Prey Area.
CONTRACTOR:	Department of Biological Sciences, University of Idaho, Moscow, Idaho 83843.
INVESTIGATORS:	Donald R. Johnson, Principal Investigator Nicholas C. Nydegger, Research Associate Dana L. Yensen, Research Technician Ellen Langril, Volunteer
PROJECT SUPPORT:	U.S. Department of the Interior, Bureau of Land Management, Contract No. YA-553-CT2-1019.

OBJECTIVES:

1. To monitor changes in vegetation and populations of major prey species in the Birds of Prey Area.

2. To integrate and analyze all prey and vegetation data collected in the Birds of Prey Area since 1974.

ANNUAL SUMMARY

Overall black-tailed jack rabbit (Lepus californicus) density in the Birds of Prey Area averaged 0.5 rabbits/ha in 1984. This value represented a sharp decline from 1983.

The livestock exclosures, fire transect lines, and fire study plots were sampled in 1984. The contract was completed, and a final report was received.

METHODS

Black-tailed Jack Rabbits

Black-tailed jack rabbits were surveyed along 10 spotlighting transects (Smith and Nydegger in press) which ran through the major vegetation types within the study area. Each transect was sampled 3 times from mid-May to mid-June totalling approximately 547 km. Data were analyzed using the computer program "TRANSECT" (Burnham et al. 1980). The locations of all kangaroo rats (Dipodomys ordii, D. microps) sighted during the jack rabbit survey were also recorded.

Exclosures

The 5 large livestock exclosures established in 1981 were sampled as specified in the Birds of Prey Exclosure Study Plan. Techniques in use on each exclosure included paired 40-sample (10-m spacing) Daubenmire transects (Daubenmire 1959, 1970), 1/300-acre (13.49 m^2) density plots (Asherin 1973), 1-m^2 stem or trend plots, and photographic documentation.

Ground squirrel hole count transects (USDI 1979) were conducted on each exclosure. In 1983, additional hole count transects were established outside each exclosure at permanently marked locations. A record of all flora and fauna seen was kept by field personnel.

Fire Transect Lines

We sampled the 2 sets or pairs of permanently marked 400-m Daubenmire transects (Daubenmire 1959, 1970) established in 1981 on big sagebrush (*Artemisia tridentata*) areas that had burned in 1980. Each set consisted of a 40-sample transect located in the burn and a parallel transect located within the native vegetation. Shrub density on each of the unburned transects was sampled with 15 1/300-acre (13.49 m^2) density plots in the manner of Asherin (1973).

Fire Study Plots

Three new paired study plots were established as controls to supplement the 5 pairs established in 1982. Fire plot control pairs were placed at the Big Sagebrush spring/fall exclosure, Winterfat exclosure, and the Shadscale exclosure. Like the previously established study plot pairs, each plot consisted of 3 permanently marked 100-ft (30.5 m) transect lines in a radial arrangement with a common origin. Each plot consisted of 2 of these radial triads. One triad of each pair was located inside the respective exclosure to prevent livestock grazing; the other was located adjacent to, but outside the exclosure fence.

All fire plots were sampled in early June. Sixty canopy coverage estimates (Daubenmire 1959) were obtained on each triad (20 per line) at 5-ft intervals. Twelve 1/300-acre (13.49 m^2) circular plots (Asherin 1973) were used on each triad to record plant density (perennials only). Each line was photographed. The frequency of occurrence for each species was also calculated for each triad.

RESULTS

The contract was completed in November 1984. A final report was received and is on file in the Boise District, BLM office. This annual report presents some results of data collected in 1984.

Black-tailed Jack Rabbits

Annual density indexes based on spotlighting showed a sharp decline in numbers between 1981 and 1982, a leveling in 1983, and a subsequent decline between 1983 and 1984 to the lowest level ever recorded since surveys began in 1977 (Table 1). A similar decline between 1983 and 1984 was observed in the big sagebrush types (Table 2). Big sagebrush types contain the highest densities in the area and appear to be the best habitat for jack rabbits (Smith and Nydegger in press).

The number of kangaroo rats seen per unit effort (Table 3) varied from 0.25 to 1.59 animals/km depending on the vegetation type. These values are similar although slightly lower than in 1983.

Table 1. Annual density estimates of black-tailed jack rabbits from spotlighting transects in the Birds of Prey Study Area, 1977-1984.

Year	Number of Rabbits Observed	Density Index[a] (N/ha)	95% Confidence Interval	Coefficient of Variation
1977	218	0.16	0.14-0.18	6.86
1978	103	0.17	0.13-0.21	10.09
1979	701	0.49	0.46-0.53	3.84
1980	807	0.48	0.43-0.53	4.98
1981	870	0.52	0.49-0.56	3.44
1982	282	0.14	0.12-0.16	6.05
1983	192	0.12	0.11-0.14	7.36
1984	59	0.05	0.04-0.07	13.41

[a] Calculated using the Exponential Power Series estimator in program TRANSECT (Burnham et al. 1980).

Table 2. Annual density estimates of black-tailed jack rabbits from spotlighting transects in big sagebrush within the Birds of Prey Study Area, 1977-1984.

Year	Number of Rabbits Observed	Density Index[a] (N/ha)	95% Confidence Interval	Coefficient of Variation
1977	60	0.23	0.18-0.29	13.01
1978	54	0.67	0.48-0.85	14.45
1979	412	0.79	0.71-0.86	5.03
1980	455	0.75	0.68-0.82	4.76
1981	466	0.95	0.86-1.04	4.75
1982	163	0.29	0.24-0.34	7.96
1983	237	0.33	0.28-0.37	6.63
1984	36	0.13	0.06-0.19	26.70

[a] Calculated using the Exponential Power Series estimator in program TRANSECT (Burnham et al. 1980).

Table 3. Number of kangaroo rats seen per unit of effort (N/km) on the spotlighting transects within selected cover types, Snake River Birds of Prey Study Area 1984.

Cover Type	Number/km
Big sagebrush	0.65
Big sagebrush/winterfat	1.59
Big sagebrush/shadscale	1.23
Winterfat	0.71
Shadscale	0.56
Shadscale/winterfat	0.25
Greasewood	1.81
Grass	0.46
All Cover Types Pooled	0.67

Exclosures, Fire Transect Lines, and Fire Plots

All exclosures, fire transect lines and fire plots were sampled in 1984. Data are on file in the Boise District Office.

Acknowledgments--We thank J. H. Doremus, W. M. Iko and C. D. Schroer of the Bruneau Resource Area for assistance in running the jack rabbit transects.

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TITLE: Raptor and Raven Nesting on the PP&L Malin to Midpoint 500 kV Transmission Line.

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COOPERATOR: Pacific Power and Light Company

OBJECTIVES:

1. Describe distribution, density, and nesting success of raptors and ravens nesting on the transmission line.

2. Identify factors influencing raptor and raven nesting on the transmission line.

3. Assess the effectiveness of artificial nesting platforms.

4. Develop management guidelines for future transmission line design and placement.

INTRODUCTION

Electrical power lines have affected raptors both adversely and beneficially (Olendorff et al. 1980, 1981; Nelson 1982). One of the principal benefits of power transmission lines is that they provide nesting substrate for birds of prey (Gilmer and Wiehe 1977; Stahlecker 1979; Lee 1980; Nelson 1982; Kochert and Steenhof 1983). Utilization of transmission lines by nesting raptors and corvids is common, especially in western North America (references cited above) and also in other parts of the world (R. Metcalf, pers. comm.). The use of power lines by large birds has raised the following questions: 1) Does nesting interfere with power transmission? 2) Can raptor nesting density and success be enhanced by the presence of transmission lines? and 3) What types of tower designs and modifications can minimize interference with transmission and at the same time increase raptor nesting density and success?

The construction of a 500 kV transmission line across southern Idaho and Oregon in 1980-81 provided government and industry biologists with an opportunity to investigate these questions. The Pacific Power & Light Company (PP&L), in cooperation with the Bureau of Land Management (BLM), agreed to construct 37 artificial nesting platforms (Nelson and Nelson 1976) along its 500 kV transmission line between Midpoint (Jerome), Idaho and Malin, Oregon (Fig. 1). Pacific Power & Light representatives and interested individuals began checking artificial nesting platforms on the line in 1981 and 1982. In November 1982, BLM Birds of Prey Research biologists agreed to survey the portion of the PP&L line in and near the Snake River Birds of Prey Area, as part of a larger, coordinated effort to survey the entire line. This report consolidates results of surveys from 1980 to 1983 and focuses particularly on findings of the 1984 survey.

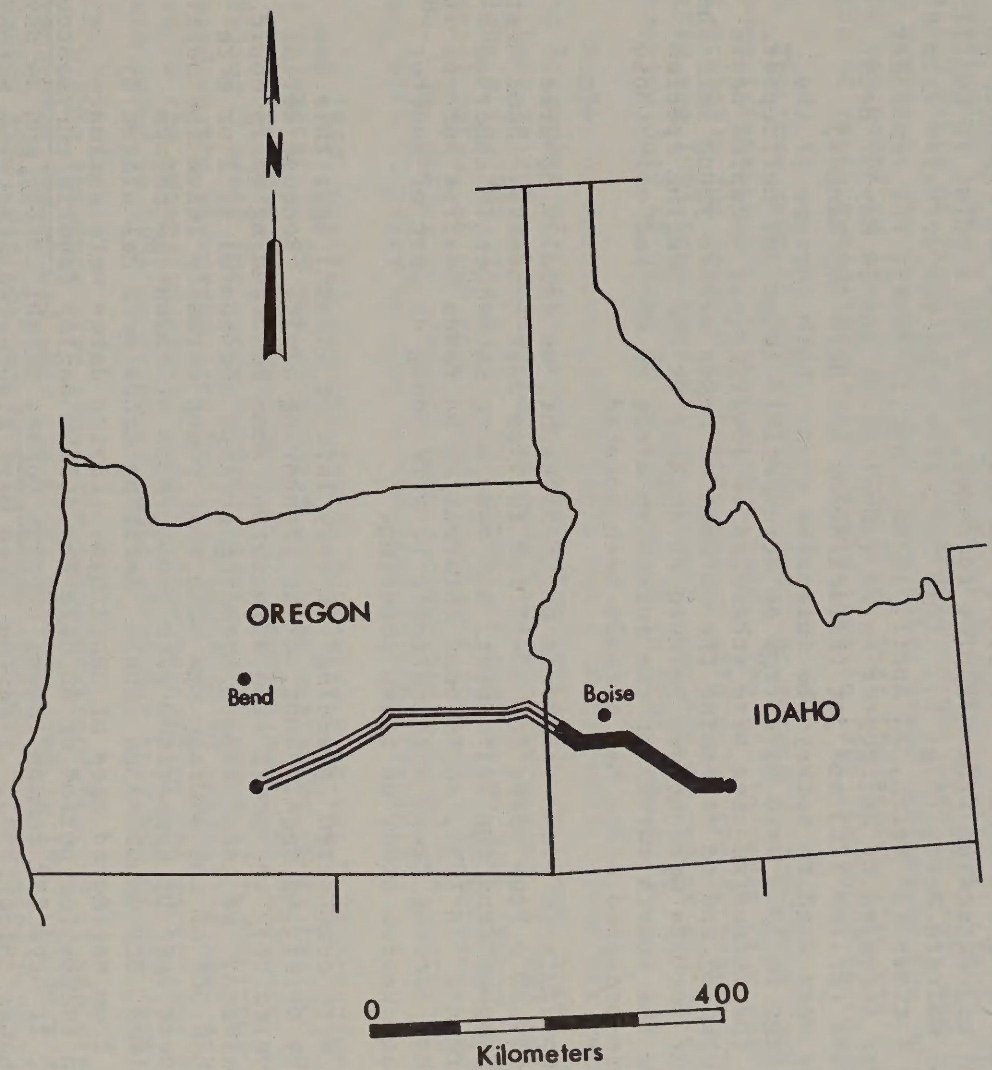


Fig. 1. Location of the Pacific Power and Light 500 kV transmission line. Intensive survey stretch is shaded.

METHODS

In 1981 and 1982, Morlan Nelson and Pacific Power & Light Company employees checked artificial nesting platforms on the line for occupancy. In 1982, additional information was obtained during patrols of the line by PP&L linemen. Aerial surveys of the entire line began in 1983. At that time, a 160-km (99 mi) intensive survey stretch was defined extending from Hagerman, Idaho to the western edge of the Birds of Prey Area at Walters Ferry. BLM biologists surveyed the intensive area twice in 1983 from a Hiller 12E helicopter. The first survey occurred on 30 March, and the second occurred on 1 and 2 June. The entire line was surveyed by PP&L biologists from a fixed wing aircraft on 1 and 2 June. In 1984, the intensive area was expanded to 216 km (134 mi) extending from Midpoint (Jerome), Idaho to a point 18 km (11 mi) west of Walters Ferry (Fig. 1). This intensive area was surveyed from a helicopter 4 times (27 March, 23 April, 16 May, and 15 June); the remainder of the line was surveyed by helicopter twice (20-21 March and 14 May). Both piston-driven (Hiller 12E) and jet (Hiller/Soloy and Bell 206 Ranger) helicopters were used to survey the intensive area. Both surveys of the extensive area in 1984 were made from an Acrospatiale Astar jet helicopter. Surveys of the intensive area were scheduled to identify all occupied nests during incubation and to determine the outcome of nests before young left the nests. Four surveys were needed because chronology of the nesting species varied. On the fourth survey of the intensive area, we checked only those towers where occupied nests had already been located.

Helicopters were flown at speeds of 70-95 km/hr; we usually hovered approximately 20 m from nests for 15-25 sec to view nest contents. Some nests were photographed from the helicopter, and some were subsequently observed from the ground. In 1984, additional information on raven nesting success was obtained when banding crews entered nests to mark young as part of another PP&L/BLM cooperative study on raven roosting.

Pairs were considered "breeding" if they laid at least 1 egg; this was confirmed by observing eggs, young, or an incubating adult. Because aerial surveys covered only the power line structures, some nonbreeding pairs could have been missed. We considered a breeding attempt successful if 1 or more young reached 80% of the average age when most young normally leave the nest. Nestlings were aged by comparison with photographs of known-age chicks (Moritsch 1983, BLM unpublished data). Hatching dates were calculated by backdating from estimated ages of nestlings. Laying dates were estimated by assuming an incubation period of 45 days for golden eagles (*Aquila chrysaetos*; Nice 1954), 21 days for common ravens (*Corvus corax*; Stiehl 1978), and 34 days for buteo hawks (Nice 1954). Fledging dates were also calculated from hatch dates, according to brood-rearing lengths presented by Steenhof (in prep.).

We assessed topographic characteristics, cultural features, and land use from topographic maps, aerial photos, and PP&L plan and profile maps of the intensive survey area. For each nest occupied in 1984 and for 54 randomly selected towers that were not used for nesting, we calculated distances to nearest road, and assessed the presence and amount of roads, cliffs, buildings, smaller power lines, and agricultural fields within a 1000 m radius of each nest and each randomly selected tower. The maintenance road following the transmission line was excluded from the analysis. Topographic variation

around each tower was calculated as the difference in elevation between the lowest and highest points within the 1000 m radius. The ratio of the differences between tower elevation and highest and lowest points was used as an index of the tower's relative topographic position.

RESULTS

Nest Density and Distribution

Most towers on the line were erected after the 1980 nesting season and before the 1981 nesting season. Raptors and ravens began nesting on the transmission line in 1981 even before it became operational (Table 1). At least 3 pairs of raptors and ravens nested on the line in 1981, and in 1982 the number of nesting raptor and raven pairs found nesting on the completed line increased to 16. In 1983, the first year the entire line was checked, 55 nests of raptors and ravens were found, and in 1984 the total increased to 79.

The true rate of colonization cannot be assessed from these data because survey intensity has increased each year. The 44% increase from 1983 to 1984 was probably due largely to better survey efforts in the extensive area. Within the 1983 intensive survey stretch, numbers of raptor and raven nests increased only 6%, from 36 in 1983 to 38 in 1984 (Table 2).

Number of occupied golden eagle nests on the entire line has ranged from 1 to 5; number of ferruginous hawk (*Buteo regalis*) nests has ranged from 1 to 9. Both golden eagle and ferruginous hawk numbers peaked in 1983 and declined slightly in 1984 (Table 1). The number of red-tailed hawk (*Buteo jamaicensis*) nesting pairs, on the other hand, increased from 2 to 13 between 1983 and 1984. The number of occupied common raven nests found has increased each year, with 55 pairs nesting on the line in 1984 (Table 1).

In 1984, nesting density in the intensive area was 0.24 occupied nests per kilometer (0.38 per mile) or 9 occupied nests for every hundred towers. In the extensive area, there were 0.07 occupied nests per kilometer (0.11 per mile) or 3 nests for every hundred towers. No eagles or ferruginous hawks nested in the extensive area in 1984, but 9 of 13 red-tailed hawk nests (69%) were in the extensive area. Seventy-five percent of the raptor and raven nests found in 1984 occurred in Idaho which has only 40% of the line.

Within the intensive area, the apparent concentration of raptors and ravens observed in and near the Birds of Prey Area in 1983 (Kochert and Steenhof 1983) was not observed in 1984. Numbers of occupied raptor and raven nests increased in the eastern half of the intensive survey area in 1984, producing a more uniform density throughout the survey stretch.

Ravens and raptors sometimes occupied nests on adjacent towers. Red-tailed hawks nested within 360 m of occupied raven nests, and ferruginous hawks nested within 103 m of occupied raven nests (Table 3). Minimum distances between conspecific nesting pairs always exceeded 1.3 km. Eagle and red-tailed hawk nests were widely separated from conspecific nests, but ravens and ferruginous hawks both nested within 2 km of conspecific nesting pairs (Table 3). Fourteen of 37 ravens in the intensive area (38%) nested within 5 km of one of the towers used by roosting ravens.

Table 1. Number of occupied raptor and raven nests found on the PP&L 500 kV transmission line, 1981-84.

Species	1981	1982	1983	1984
Golden Eagle	1	2	5	4
Ferruginous Hawk	1	3	9	7
Red-tailed Hawk	0	2	2	13
Common Raven	1	9	39	55
TOTAL	3	16	55	79

Table 2. Number of occupied raptor and raven nests on the portion of the PP&L 500 kV transmission line between Hagerman and Walters Ferry, Idaho, 1983-84.

Species	1983	1984
Golden Eagle	3	3
Ferruginous Hawk	8	7
Red-tailed Hawk	0	1
Common Raven	25	27
TOTAL	36	38

Table 3. Minimum distances (km) between adjacent occupied nests on the PP&L 500 kV transmission line, 1984 (intensive survey stretch only).

	Golden Eagle	Ferruginous Hawk	Red-tailed Hawk	Common Raven
Golden Eagle	30.36	7.89	8.38	1.07
Ferruginous Hawk		1.94	8.12	0.10
Red-tailed Hawk			28.02	0.36
Common Raven				1.32

Nest Site Selection

In 1983 and 1984, 13 of 87 occupied raptor and raven nests in the intensively surveyed areas (15%) were on the specially-designed artificial nesting platforms (Fig. 2). Platforms, however, were selected by half (13 of 26) of the hawk and eagle nesting pairs; ravens never used the artificial platforms. A preference by hawks and eagles for the artificial platforms is apparent when one considers that only 2% of the towers in the intensive survey area contain platforms. Eagles and hawks also used the "C" and "X" positions in the upper crossarm (Fig. 2), and ferruginous hawks also used the "W" or "waist" position lower in the tower structure (Fig. 2).

Ravens used the "X" position in 57 of 61 (93%) nesting attempts (Fig. 2). In one case, a raven pair nested in the "X" position of a tower that contained a nesting platform. Ravens also nested in the "C" position on 3 occasions and on the waist once. Apparent preference for the "X" position may be related to its denser latticework that could provide a more stable nesting substrate than the "C" or "W" positions. The avoidance of platforms by ravens may have been due to a preference for nest sites high in the tower structure.

Twenty-nine of the 37 artificial platforms were not used in 1984, and 30 were not used in 1983. Since the beginning of the survey, raptors have nested in 11 different artificial platforms. All 11 platforms that have been used had been "baited" with sticks; 12 of the 26 unused platforms (46%) had not been "baited." All platforms used in 1984 were in the intensive area. Only 2 of 25 platforms in the extensive area have been used in earlier years. In the intensive area, 9 of 12 platforms were used in either 1983 or 1984.

Characteristics surrounding towers used by raptors and ravens in the intensive study area in 1984 were contrasted with those around a random sample of unused towers to identify factors that may have influenced tower selection.

The first set of variables represented indexes to levels of human activity. Roads did not appear to influence tower selection by either raptors or ravens. Towers used by raptors were slightly farther from roads than were unused towers, and towers used by ravens were slightly closer to roads than were unused towers (Table 4). Neither difference, however, was statistically significant ($t = 0.90$, $\underline{P} = 0.38$; $t = 1.25$, $\underline{P} = 0.22$). A smaller proportion of raptors and a higher proportion of ravens nested within 1000 m of paved or gravelled roads, but again relative frequencies did not differ significantly ($\chi^2 = 0.23$, $\underline{P} = 0.63$; $\chi^2 = 0.47$, $\underline{P} = 0.49$). The amount of road within a 1000 m radius of towers showed the same non-significant trends ($t = 0.23$, $\underline{P} = 0.82$; $t = 1.09$, $\underline{P} = 0.28$).

Raptors and ravens did not seem to avoid buildings or farm fields, nor were they attracted to them (Table 4). The proportion of randomly selected towers that had buildings within a 1000 m radius (20%) was identical to the proportion of towers used by raptors that had nearby buildings (Table 4). The proportion of raven nests with buildings in the immediate surrounding area was only slightly higher (23%). The amount of agriculture surrounding unused towers was slightly but not significantly higher than the amount around raptor ($t = 0.78$, $\underline{P} = 0.44$) and raven ($t = 0.88$, $\underline{P} = 0.38$) nesting towers (Table 4), but the proportion of unused towers with farm fields less than 1000 m away

Golden Eagle (N=7)

C -- 14

X -- 29

P -- 57

W -- 0

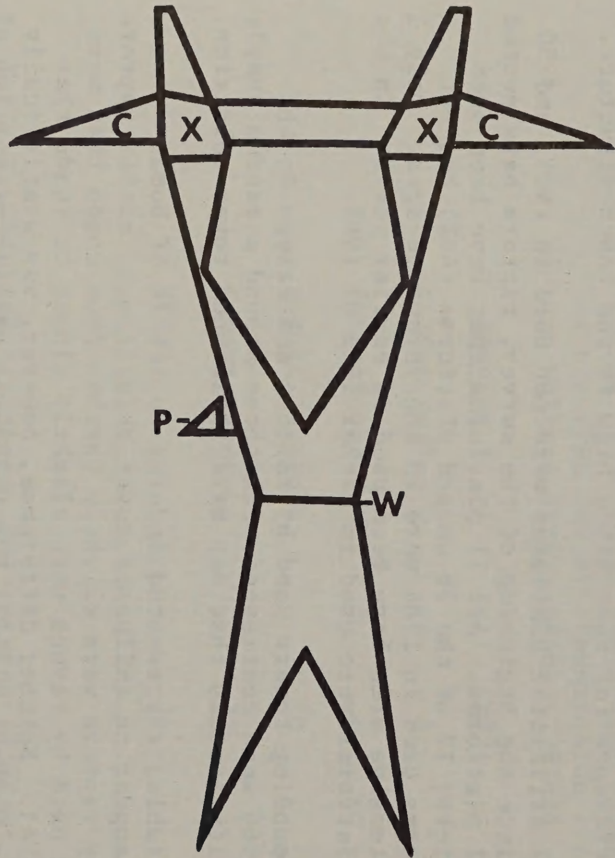
Ferruginous Hawk (N=15)

C -- 13

X -- 27

P -- 47

W -- 13



Red-tailed Hawk (N=4)

C -- 0

X -- 50

P -- 50

W -- 0

Common Raven (N=61)

C -- 5

X -- 93

P -- 0

W -- 2

Fig. 2. Percent of raptor and raven nesting attempts in relation to tower position for the intensive study areas, 1983-84. Sample sizes are shown in parentheses.

Table 4. Cultural and topographic features within 1000 m of towers in the intensive survey area.

	Towers Used By Raptors in 1984	Towers Used By Ravens in 1984	Towers Used By Either Raptors or Ravens in 1984	Towers Not Used For Nesting in 1984
$\bar{x}$ distance to nearest road(m)	334	217	249	277
% with paved or graveled roads	33%	54%	48%	44%
$\bar{x}$ km of roads	5233	5979	5772	5388
% with 1 or more buildings	20%	23%	22%	20%
% with agriculture	40%	44%	43%	44%
$\bar{x}$ ha agriculture	166	180	176	251
% with cliff > 15 m high	7%	10%	9%	9%
$\bar{x}$ linear distance of cliff (m)	5	5	5	5
% with other power lines	87%	72%	76%	67%
$\bar{x}$ m of distribution lines	198	705	565	507
$\bar{x}$ m of other transmission lines	1629	1300	1392	1318
$\bar{x}$ m of all other power lines	1828	2005	1956	1825
topographic variation (m)	48	57*	54*	41
Relative topographic position	1.25	2.41**	2.09**	1.19

* significantly different from unused towers, $0.05 < P < 0.10$.

** significantly different from unused towers, $P < 0.05$.

(44%) was similar to the proportions of towers used by raptors (40%) and ravens (44%).

The second set of variables represented features that may have provided alternative nesting sites. But neither the frequency or amount of cliffs or power lines within a 1000 m radius seemed to affect whether a tower was used or unused (Table 4). Only 5 nesting towers and 5 randomly selected towers were within 1000 m of a cliff greater than 15 m high, and the average amount of cliff near used and unused towers was identical (Table 4). A high proportion of used and unused towers were within 1000 m of other power lines, and the average linear distances of all types of lines were similar for all groups (Table 4). Mean linear distance of distribution lines around towers used by raptors was less than half that around unused towers, but mean length of transmission lines was 23% higher around raptor nests than around unused towers. Neither difference was statistically significant ($t = 1.6$, $\underline{P} = 0.12$; $t = 0.82$, $\underline{P} = 0.42$).

Topographic relief was the only component that provided any significant insight into factors affecting tower selection. Topographic variation, as measured by the difference between the highest and lowest points within a 1000 m radius of the tower was significantly higher ($t = 1.78$, $\underline{P} = 0.08$) at towers used by ravens than at unused towers. In addition, the relative position of towers used by ravens in relation to surrounding topography was significantly higher than that of unused towers ($t = 2.22$, $\underline{P} = 0.03$). This pattern, however, was not observed among raptors ($t = 0.16$, $\underline{P} = 0.87$).

Nest Site Fidelity

Ravens and raptors tended to nest in areas and towers that had been previously used for nesting. Three of 4 golden eagle pairs nesting on the transmission line in 1984 used nests that had been used in 1983. The fourth pair returned to nest on the artificial platform on Tower 3/49 that it had used in 1982. This pair had nested on a cliff 400 m from the tower in 1983 (Kochert and Steenhof 1983). Two eagle pairs (at Towers 3/68 and 4/7) have used the same artificial platform for 3 consecutive years. Only 2 eagle nests on the transmission line have not been re-used. The platform on Tower 2/346 was used only in 1981, and a nest in the "C" position of Tower 3/55, which was destroyed by wind during the 1983 nesting attempt, has not been rebuilt.

In 1984, 21 of 27 raven pairs in the 1983 intensive study area nested within 2 towers of a nest that had been occupied in 1983. Because these 1983 and 1984 nests were less than 1 km apart, we considered them to be part of the same "territory" or breeding area. Thirteen of the 21 raven pairs that nested in a 1983 territory also used the same tower in 1984, and 7 of these nested in the same position on the tower. Four nested in an adjacent tower, and 4 were 2 towers away. Four raven territories that had been occupied in 1983 were not occupied in 1984, but 6 new territories were occupied in 1984.

Five of the 7 ferruginous hawk pairs that nested on the transmission line in 1984 used a territory that had been occupied in 1983. Four of these used the same nest that was used in 1983; the fifth pair nested 2 towers east of a tower used for nesting in both 1982 and 1983. One of the nests used by ferruginous hawks (4/104) has been used consecutively for 3 years (1982-84), and another (3/90) has been used for 3 non-consecutive years (1981,1983-84).

Three territories that had been occupied by ferruginous hawks in 1983 were vacant in 1984, but ferruginous hawk pairs used 2 new territories in 1984.

Nesting Success and Productivity

All pairs that we located on the transmission line laid eggs. Some nonbreeding territorial pairs may have been missed because our checks of empty nests were very brief and we did not search for birds off the power line. Estimated nesting success for pairs in the intensive area was 50% for eagles, 100% for ferruginous hawks, 75% for red-tailed hawks, and 83% for ravens (Table 5). One red-tailed hawk and 1 raven pair renested after their first attempts apparently failed during incubation. Young fledged per pair averaged 0.5, 2.8, 2.0, and 3.2 for eagles, ferruginous hawks, red-tailed hawks, and ravens, respectively (Table 5).

Preliminary analysis suggests that productivity of eagles and red-tailed hawks on the power line was similar to that of conspecific pairs nesting on nearby cliffs in 1984, but sample sizes were too small to assess statistical differences. Ferruginous hawks and ravens nesting on the transmission line appeared to have better productivity than their conspecific counterparts nesting on other substrates. Ferruginous hawk pairs on the line fledged 1.6 times more young per pair than pairs nesting in the surrounding area in 1984, and ravens on the PP&L line fledged 1.3 times as many young per pair as the long term average rate for ravens in the Birds of Prey Area.

Nesting success of golden eagles on the transmission line appeared to be related to nest placement. Three of 4 eagle nesting attempts on platforms in the intensive area during 1983-84 were successful compared with 0 of 3 attempts in other portions of the tower (Table 6). Wind apparently destroyed 2 eagle nests; 1 in the "X" position of a tower in 1984, and 1 in the "C" position of a tower in 1983. Nest position appeared to be less important for buteos because nest success was similar to but slightly lower than on other parts of the tower (Table 6).

Ravens nesting on the transmission line towers experienced hazards other than wind. In 1984, 4 dead young ravens were found entangled in the tower lattice. Apparently, these birds attempted to land on a diagonal stanchion and slid down, catching their feet in the angular joint between the vertical and diagonal stanchions. It is difficult to estimate the extent of this problem, but the 4 ravens that died represent 4% of the estimated number of young that fledged from the intensive area.

Nesting Chronology

In 1983-84, hatching dates in the intensive study area averaged 26 April for golden eagles, 29 April for common ravens, 20 May for ferruginous hawks, and 31 May for red-tailed hawks (Fig. 3). Golden eagles were also the first to lay eggs, followed by ravens and the 2 hawk species. Hatching dates did not differ significantly between 1983 and 1984 (2-way analysis of variance; $F = 0.68$, $\underline{P} = 0.41$). In both years there were 2 distinct periods of hatching on the power line. Mean hatching dates of ravens and eagles nesting on the power line did not differ significantly, nor did hatching dates of the 2 hawk species (Duncan's Multiple Range Test, $\underline{P} > 0.05$). Differences between the two subsets of species, however, were significant ($\underline{P} < 0.05$).

Table 5. Nesting success and productivity of raptors and ravens on the PP&L transmission line (intensive survey stretch), 1984.

Species	N	% Pairs Successful	Young Fledged Per Pair
Golden Eagle	4	50	0.50
Ferruginous Hawk	6*	100	2.80
Red-tailed Hawk	4	75	2.00
Common Raven	33**	83	3.15

*includes only nesting attempts where outcome was determined

**based on the Mayfield (1961) model for estimating nest success

Table 6. Raptor nesting success (% of attempts successful) on artificial platforms and other tower positions in the intensive survey area, 1983-84. Sample sizes in parentheses.

Species	Platform	Tower
Golden Eagle	75 (4)	0 (3)
Ferruginous Hawk	75 (4)	100 (3)
Red-tailed Hawk	50 (2)	67 (3)

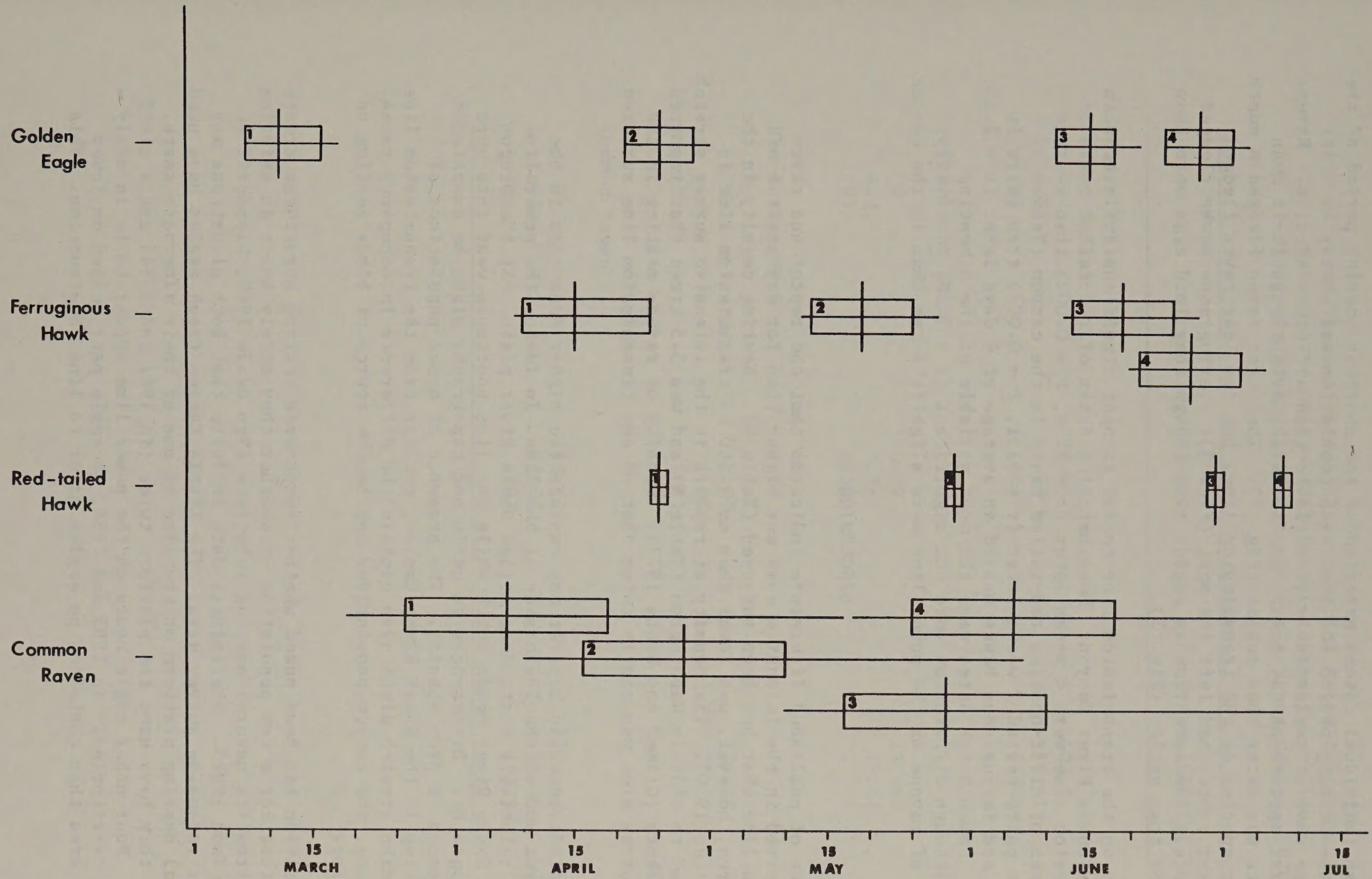


Fig. 3. Nesting chronology of raptors and ravens on the PP&L 500 kV transmission line, 1983-84. Laying dates are designated by "1", hatching dates by "2", attainment of 80% of average fledging age by "3", and departure from the nest by "4". Vertical lines indicate means, horizontal lines show ranges, and rectangles illustrate 1 standard deviation on each side of the mean.

Although individual ravens experienced the shortest nesting period of the 4 species, the nesting period for the raven population was nearly as protracted as that of eagles and more variable than all other species. Ravens were the first species on the power line to hatch, even though their mean hatching date was later than eagles (Fig. 3). The first raven fledged a month before other species on the transmission line, but the last raven fledged after the last raptor had left its nest (Fig. 3). Ferruginous hawks fledged at approximately the same time as eagles even though they laid eggs more than a month later than eagles (Fig. 3).

Raptors on the transmission line tended to nest significantly later than pairs in the Snake River Canyon. Mean hatching dates of red-tailed hawks on the transmission line were 4 weeks later ($t = 22.8$, $\underline{P} = 0.002$) than average hatching dates of cliff-nesting red-tailed hawks in the canyon (Table 7). Golden eagle pairs nested 2 weeks later ($t = 6.51$, $\underline{P} = 0.007$) than pairs in the canyon, and ferruginous hawks nested an average of 4 days later ($t = 2.12$, $\underline{P} = 0.046$). Raven hatch dates were the most variable of the 4 nesting species. Although differences were not significant ($t = 1.43$, $\underline{P} = 0.127$), hatch dates of ravens on the power line were slightly later than in the canyon (Table 7).

DISCUSSION

A review of published literature indicates that the raptor and raven density observed in the intensive area was higher than for any stretch of transmission line that has been surveyed (Table 8). Nesting density in the extensive area, however, was lower than on a 500 kV transmission line in Washington (Lee 1980). The density of raptors in the intensive survey stretch was identical to that in Washington (Table 8) and was 3.5 times that reported for North Dakota (Gilmer and Wiehe 1977). Density of ravens nesting in the intensive survey area was nearly twice that of any transmission line surveyed (Table 8).

Gross differences in habitat may explain the higher densities in the intensive area and on the Idaho side of the line. In Idaho, the power line follows the relatively flat, deep-soiled Snake River plain. At the Oregon border, the Snake River heads north while the line continues west into more rolling topography. Differences in soils and topography might be associated with differences in prey density. The presence of dense populations of raptors nesting in the Snake River Canyon, not far from the transmission line along the Idaho stretch might also explain the difference in occupancy rates along the line; the canyon populations may be the source of birds nesting on the power line.

The question has been posed whether human-made nesting structures create nesting habitat for a new population or whether they merely shift an existing population from its natural nesting substrate (Van Daele 1980, Olendorff et al. 1981, Nelson 1982). Preliminary data indicate that both situations may occur in our intensive survey area. The Little Canyon Creek eagles have used an artificial nesting platform on the line as one of their alternate nests. Since 1981, they have used the platform twice (in 1982 and 1984) and a cliff nest twice. Four other eagle nests on the power line appear to be in newly established territories. In 1983 and 1984, an eagle pair nested on Tower 3/119 in an area that contained no eagles prior to line construction. This

Table 7. Comparison of mean julian hatching dates for raptor and raven nests on the PP&L 500 kV transmission line, 1983-84 and on cliffs in the Snake River Canyon, 1970-83.

	Transmission Line	Canyon Cliffs
Golden Eagle		
$\bar{x}$	116.25	102.21
s.d.	4.19	10.41
(N)	(4)	(432)
Ferruginous Hawk		
$\bar{x}$	140.92	136.62
s.d.	6.26	8.54
(N)	(13)	(66)
Red-tailed Hawk		
$\bar{x}$	151.00	123.48
s.d.	1.00	11.37
(N)	(2)	(283)
Common Raven		
$\bar{x}$	119.63	116.68
s.d.	12.07	13.49
(N)	(49)	(271)

Table 8. Nesting densities of raptors and ravens on transmission lines.

Location	km Line Surveyed	Nests/km Raptors	Ravens	All Species	Source
Washington & Oregon	4290	0.01	0.01	0.03	Lee 1980
Washington	241	0.07	0.09	0.17	Lee 1980
North Dakota	1424	0.02	---*	0.02	Gilmer & Wiehe 1977
PP&L 500 kV Intensive Area	216	0.07	0.17	0.24	This study
PP&L 500 kV Extensive Area	381	0.02	0.05	0.07	This study
PP&L 500 kV Entire line	597	0.04	0.09	0.13	This study

*Did not report raven nesting.

pair nested between 2 traditional eagle territories in the canyon that continued to be occupied after establishment of the new territory. The other 3 eagle pairs nesting on the power line nested in areas more than 15 km from the nearest natural nesting substrate and appear to be newly established.

We are uncertain how many of 10 ferruginous hawk nests identified on the intensive stretch of the power line are within newly established territories. At least 1 pair apparently shifted from a natural substrate nest in 1982 (M. Nelson pers. comm) and has nested on the tower since. It is possible that some of the other ferruginous hawk territories as well as those of red-tailed hawks have been newly established, but this will require further investigation.

Occupancy rates at traditional raven nesting territories within 1.6 km of the PP&L line suggest that some of the raven nests on the line are in newly established territories. In 1980, 9 territories between Miles 115 and 123 were known to be occupied by ravens prior to line construction. In 1984, at least 5 of these territories were known to be occupied. This total coupled with the 6 occupied nests on the line yields a minimum net increase of 2 pairs in the area. Because the natural substrate nests were not visited until mid brood-rearing, we may have missed some nonbreeders and early failures; this would suggest an even larger increase that could be attributed to the line. Between Miles 100 and 114, the 5 raven pairs that nested on the powerline in 1983 and 1984 were more than 2.6 km from any known traditional nesting site. Because the nearest traditional territory was occupied in both 1983 and 1984, all 5 nests on the line appear to be in newly established territories.

In addition to creating new nesting habitat for raptors and ravens, the power line may provide better nesting habitat for some species. Nests on the transmission towers are clearly inaccessible to terrestrial predators. This feature appears to provide a particular advantage to ferruginous hawks, whose nests are typically on or near the ground and vulnerable to predation (BLM, unpublished data). The higher productivity of ferruginous hawks on the power line may reflect this protection. Nelson and Nelson (1976) postulated that tower nests are also better than cliff eyries with southern exposures because of shade provided by the tower beams and cross braces. The artificial platforms on the PP&L line were designed specifically to provide shade (Nelson and Nelson 1976), and we observed that nests in the "X" position received at least 35% shade during mid-afternoon. Increased air flow around nests on transmission towers may provide an additional advantage over nest sites on cliff walls. Despite the fact that raptors and ravens on the power line nested later than those in the canyon, no nestlings from the power line were found to have died from heat prostration.

Artificial platforms may further enhance the suitability of towers for nesting. Platforms may reduce nest loss due to high winds, for example. This advantage may be most important to golden eagles whose large, bulky nests appear to be less stable in the tower lattice than are nests of hawks and ravens. Ferruginous hawk nests on North Dakota transmission line towers, however, were also subject to destruction by wind (Gilmer and Wiehe 1977).

Birds nesting directly over insulators could present problems to power companies if nesting material and fecal matter fall on and contaminate insulators (Lee 1980, Olendorff et al. 1980). In 1983 and 1984, we observed that only 7% of the birds nested in the "C" position above the insulators; 75%

nested in the "X" position which is above but between the insulator strings (Fig. 2). All remaining nests (18%) were below the insulators, and no birds nested on the upper bridge above the center insulator string. The apparent preference by raptors for the artificial nesting platforms may provide some management opportunities. Platforms could be used as tools designed to lure birds away from locations where problems with insulators could occur. Such an approach was unsuccessful on a 230 kV transmission line in Colorado (Stahlecker 1979), but the placement of platforms low in the towers and facing the middle of the tower structure may have interfered with platform effectiveness in that study. Artificial platforms on the PP&L 500 kV line appear to have been more successful in attracting raptors, but ravens still prefer other portions of the towers.

The low use of platforms in the extensive area may be related to: 1) unsuitable foraging habitat in the surrounding terrain; 2) lack of nearby nesting populations to serve as sources of colonizing birds; or 3) lack of sticks in the platforms that might attract avian nesters. The relative importance of each of these explanations could be ascertained from a series of experiments and analyses. We suggest that empty, unused platforms be provided with sticks prior to the 1985 nesting season to determine if the presence of sticks influences whether or not birds nest in platforms. Analyses of prey and vegetation around towers might reveal why some towers are used and others are not. Preliminary data indicate that topographic relief may play a role in nest site selection. More refined measures of topographic position should be employed to define this relationship more precisely. If further analyses of prey, vegetation, and topography do not reveal why towers in the extensive area are not used, hacking experiments could be conducted to determine if lack of use is due to lack of birds.

Plans for Next Year

Additional information is needed to supplement data on occupancy and productivity gathered in 1983 and 1984. Objectives for the 1985 field season should be to identify all occupied nests on the entire line and to determine nesting success and productivity in the intensive area and adjacent nesting habitat. Surveys should be timed to gather the maximum amount of information with a minimum amount of flight time.

A complete occupancy survey should include 1 flight soon after all attempts have been initiated and an earlier flight to locate attempts that fail early. In 1983-84, all attempts had been initiated by 19 May, and most eagle and raven pairs were mid-way through incubation by the first week in April (Fig. 3). Assuming that chronology in the extensive area is similar to that in the intensive area, flights during the first week in April and the third week in May should locate all pairs nesting on the line.

Accurate assessments of raptor reproductive success must be based on at least 2 survey flights (Postupalsky 1974; Fraser et al. 1983, 1984): 1 to identify occupied territories during incubation and 1 to count number of young produced just prior to fledging. Based on the variation in nesting chronology among the 4 species, at least 4 flights will be needed to accurately assess productivity of raptors and ravens nesting on the power line in the intensive survey area.

The first flight should be scheduled after the last clutch has been laid but before the first brood hatches (Fraser et al. 1983). Fig. 3 demonstrates graphically that no single survey date would identify individuals of all species during incubation. A flight between 8 and 12 April would identify all eagles and most ravens during incubation (Fig. 3), and a second flight between 3 and 7 May would locate all hawks and nearly all of the ravens that were not located on the first flight.

The final series of checks should be conducted after the young have reached 80% of the average fledging age but before young leave the nest. Again, Fig. 3 illustrates that a single survey would not find all nests at this stage. A flight between 23 and 27 May would locate most ravens at the appropriate stage, and a flight between 23 and 27 June would locate all eagles, most ferruginous hawks, and some ravens. Success of red-tailed hawk pairs might have to be ascertained from a follow-up ground survey.

Other considerations to be remembered when scheduling surveys include gathering comparative data for cliff-nesting eagles and coordinating with the raven roosting study. Because golden eagle nesting chronology in the canyon is 2 weeks earlier than on the power line, both the incubation and fledging surveys should be 2 weeks earlier in the canyon.

If ravens are to be banded at power line nests in 1985, a flight during the first week of May would locate and age ravens that would be the earliest to fledge, and a flight in late May would locate and age the remaining successful raven nests. Banding visits could confirm success of nests that terminated between late May and late June.

Based on all of the considerations above, target dates for 1985 nesting surveys are shown in Table 9.

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Table 9. Target dates for survey flights for the 1985 nesting season.

Target Date	Spread Period	Survey Area	Purpose
20 March	18 - 22 March	Snake River Canyon	Locate incubating eagles
5 April	3 - 7 April	PP&L 134-371	Locate early nests
10 April	8 - 12 April	PP&L 1-133	Locate incubating eagles and ravens
5 May	3 - 7 May	PP&L 1-133	Locate incubating hawks and ravens; Age eagles and ravens
20 May	18 - 22 May	PP&L 134-371	Locate remaining nests
25 May	23 - 27 May	PP&L 1-133	Ascertain success of early ravens; Locate late nests; Age hawks, eagles, and remaining ravens
10 June	8 - 12 June	Snake River Canyon	Ascertain success of cliff-nesting eagles; Spot-check some power line nests on return
25 June	23 - 27 June	PP&L 1-133 (Spot-check)	Ascertain success of remaining pairs

TITLE: Implications of Raven Communal Roosting to Operation and Maintenance of the Midpoint to Malin 500 kV Transmission Line.

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COOPERATORS: Pacific Power and Light Company

OBJECTIVES:

1. To identify the size and composition of the roosting population.
   1a. To assess the extent of the contamination situation on the transmission line.

2. To describe patterns of roosting among towers and within towers.
   2a. To examine the feasibility of treatments (i.e., shielding or perch discouragers) in reducing insulator contamination.

3. To determine the environmental factors influencing raven roosting.
   3a. To determine whether potential roost locations can be predicted.

ANNUAL SUMMARY

Ravens have roosted on the Midpoint to Malin 500 kV transmission line since at least 1982. Concern has been expressed that accumulation of raven feces on insulators of roost towers may reduce operational performance of the line. During 1982, Pacific Power and Light Company (PP&L), in cooperation with the Bureau of Land Management (BLM), initiated research to determine the implications of raven roosting to operation and maintenance of the transmission line. BLM agreed to provide baseline biological information necessary to help define the most cost-effective means to control contamination. The objectives of 1984 research were to determine: 1) the size and composition of the roosting population, 2) patterns of roosting among towers and within towers, and 3) environmental factors influencing raven roosting.

Nine raven roosts involving 63 towers were located during 1984; however, not all roosts were occupied simultaneously. Seven of these 9 roosts were between miles 101-156. The largest roost (Initial Point Roost) was located between miles 107-113. Trends in numbers of birds at the Initial Point Roost were representative of trends observed over the entire line. Numbers of birds increased gradually from spring to early summer. Thereafter, numbers increased more rapidly until mid-July when a peak of 2103 ravens was observed. It is likely that this rapid increase was at least partially due to an influx of nesting ravens and their recently fledged young. Sightings of marked ravens confirmed that young from both natural substrate and tower nests roosted on the transmission line, and that they travelled up to 24 km from their nests to do so. After the peak count, numbers of ravens and occupied roosts declined. By mid-September, 4 of the 7 roosts were evacuated, including the Initial Point Roost. The number of towers used at each roost also changed throughout the year. At the Initial Point Roost from 4-17 towers were used on a single night.

Times of arrival at and departure from roosts were relatively constant throughout the year. Times of first arrival averaged 22 min before sunset, while times of last departure averaged 15 min after sunrise. Ravens also showed consistent affinities for the upper sections of towers: over 80% of the ravens observed at the Initial Point Roost roosted above insulators. Wind velocity was the only weather variable related to use of tower sections. When wind velocity was >8 km/hour, a higher proportion of ravens roosted on lower tower sections than when winds were <8 km/hour.

Although roosting was concentrated above insulators, ravens were not always evenly distributed laterally across upper tower sections. This was evidenced by occasions when contamination was concentrated on 1 or 2 strings of insulators without a trace of contamination on adjacent strings. Levels of contamination were significantly correlated with numbers of ravens roosting above insulators. The amount of noise produced by conductors was also significantly correlated with contamination levels: as contamination levels increased, so did the amount of noise.

Miles 101-156 supported 7 of the 9 raven roosts located on the line. This segment of line closely follows the Snake River plain, which is characterized by relatively flat terrain and deep, fertile soils. Roost towers were located on flatter terrain and were closer to agricultural land than were towers not used for roosting. There was more agricultural land within 1 km of roost towers than non-roost towers. The presence of roads did not differ significantly between roost and non-roost towers; however, the amount of primary (gravelled or paved) road was significantly less near roost than non-roost towers. The presence of buildings also did not differ significantly between roost and non-roost towers. The distribution of raven roosts did not appear to be related to the distribution of nesting raptors on the transmission line; however, the density of raven nests was highest on the segment of line which supported 7 of the 9 raven roosts (101-156). Locations of historical natural substrate roosts may be associated with the locations of roosts on the power line. Historical roosts were located within 1 km of the Initial Point and Swan Falls Road roosts. Human activity temporarily disrupted roosting on 3 occasions. Two attempts to mark ravens with dye at roost towers caused ravens to temporarily use adjacent towers.

The presence of a vehicle parked within 200 m of a roost tower caused ravens to shift roosting to an adjacent tower approximately 600 m from the vehicle.

Patterns of roosting may have been associated with trends in food availability. Ravens fed primarily on small mammals and insects from May through August; grasshoppers were the most common food item from mid-June through August. Grasshoppers usually begin hatching in mid-May and steadily increase in numbers until August when peak numbers occur. Thereafter, grasshopper populations rapidly decline as colder temperatures and more precipitation occur. Peak numbers of grasshoppers and roosting ravens and their subsequent declines roughly coincided.

These findings indicate the potential for a large contamination problem on the transmission line. Patterns of roosting also present difficulties in attempting to control contamination: ravens preferred to roost on tower sections above insulators and were inconsistent in their use of towers and segments of line and the number of days which they occupied roosts. Eradication of the ravens to eliminate contamination is both illegal and impractical considering the number of birds involved and the likelihood of the roosting population involving transient birds. Disturbance tactics also seem to hold little promise: ravens were only temporarily displaced from roost towers by disturbance, and ravens disturbed from their normal roost towers simply moved to other, adjacent towers. Feasible options for controlling contamination on the transmission line include shielding insulators of roost towers and discouraging ravens from roosting on sections situated above insulators by mechanical means.

Potential roost locations may be predictable. Roosts tended to be located in areas of relatively low topographic relief and near agricultural land.

METHODS

Locating Roosts

A study area was defined which encompassed a segment of line extending 32 km east (miles 83-102) and 32 km west (miles 106-125) of the main 1983 use area (miles 103-105, Steenhof 1983) (Fig. 1). Miles 126-132 were added to the study area because of this segment's proximity to the Snake River canyon where there is an abundance of nesting ravens. Roosts were located in the study area via aerial and ground surveys conducted at least once a month beginning in March and April, respectively. Aerial surveys were flown in a single-engine, fixed-wing aircraft, maintaining an altitude of 46-61 m above ground level and an airspeed of approximately 113 km/hour. Aerial surveys began 0-15 min before sunset and lasted approximately 45 min. Locations of occupied towers were recorded. Towers were considered "occupied" if 3 or more ravens were observed on them during an aerial survey, and "unoccupied" if fewer than 3 ravens were observed during 2 successive aerial surveys and the roost watches performed between them. Ground surveys were driven along maintenance roads which ran immediately adjacent to the transmission line. When some towers were inaccessible due to poor road conditions, observations were made from less than 0.8 km using

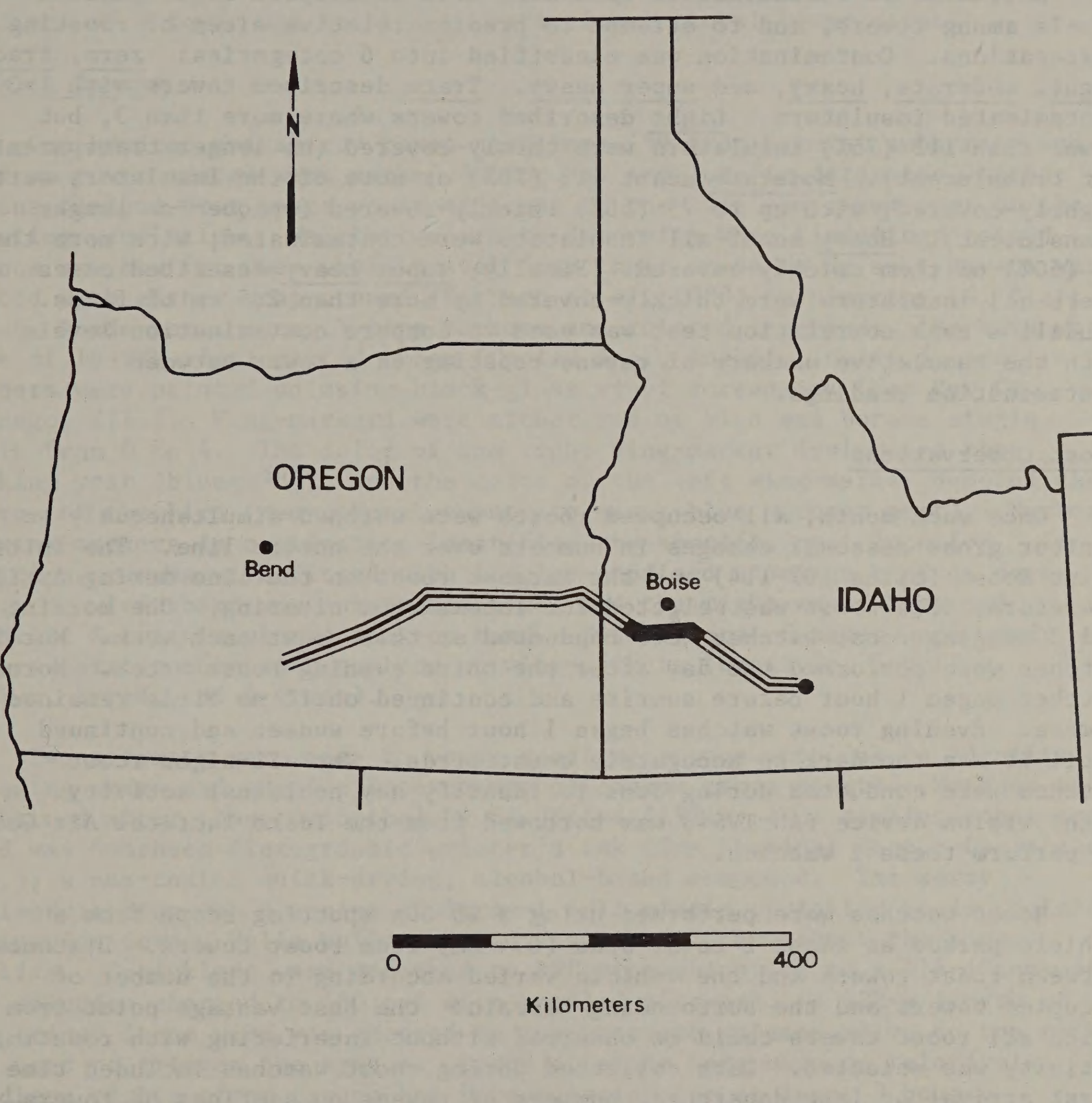

Figure 1. Location of the 1984 study area (miles 83-132, shaded).

a 15-60x spotting scope. Contamination on insulators was used to locate suspected roosts during ground surveys.

Aerial surveys of miles 1-365 were conducted on 21 March and 1 June, and a ground survey of the entire line was conducted in mid-summer by PP&L line patrolmen as part of routine maintenance. Roosts outside of the study area were located during these latter surveys.

Estimates of contamination were also used to compare contamination levels among towers, and to attempt to predict relative sizes of roosting aggregations. Contamination was classified into 6 categories: zero, trace, light, moderate, heavy, and super heavy. Trace described towers with 1-3 contaminated insulators. Light described towers where more than 3, but fewer than 113 (75%) insulators were thinly-covered (no longer transparent, but translucent). Moderate meant 113 (75%) or more of the insulators were lightly-covered, with up to 75 (50%) thickly-covered (opaque--no longer translucent). Heavy meant all insulators were contaminated, with more than 75 (50%) of them thickly-covered. Finally, super heavy described cases where all insulators were thickly-covered by more than 2.5 cm of feces. Kendall's rank correlation test was used to compare contamination levels with the cumulative numbers of ravens roosting on a tower between contamination readings.

Roost Observations

Once each month, all occupied roosts were watched simultaneously to monitor gross seasonal changes in numbers over the entire line. The Initial Point Roost (miles 107-114) was the largest roost on the line during April; therefore, this roost was selected for intensive monitoring. One morning and 3 evening roost watches were conducted at this roost each week. Morning watches were performed the day after the third evening roost watch. Morning watches began 1 hour before sunrise and continued until no birds remained on towers. Evening roost watches began 1 hour before sunset and continued until it was too dark to accurately count birds. Two all-night roost watches were conducted during June to identify any nocturnal activity. A night vision device (AN-TVS4) was borrowed from the Idaho Tactical Air Guard to perform these 2 watches.

Roost watches were performed using a 15-60x spotting scope from a vehicle parked at least 1 tower span (0.4 km) from roost towers. Distances between roost towers and the vehicle varied according to the number of occupied towers and the surrounding terrain: the best vantage point from which all roost towers could be observed without interfering with roosting activity was selected. Data collected during roost watches included time of first arrival or last departure, numbers of ravens on sections of towers, temperature, wind speed and direction, light intensity, amount and type of precipitation, and cloud cover. These data were recorded at 5 min intervals. Time of first arrival was defined as the time after which there was always at least 1 raven perched on the tower. Time of last departure was the time when the tower was first completely emptied. Wind speed was measured using a Dwyer hand-held wind meter (Carolina Biol. Supply Co., Burlington, N.C.), and light intensity was measured using a photometer (Science and Mechanics Instrumentation Div., New York, N.Y.).

Regression analysis was used to assess whether variations in total roost counts, use of tower sections, and times of first arrival and last departure were related to variations in weather conditions (i.e. wind velocity, cloud cover, and temperature). Tower sections were divided into 2 groups: upper sections were those situated above insulators and lower sections were those situated below insulators. Chi-square analysis was used to assess whether the proportion of ravens roosting on lower sections was higher when wind velocity was >8 km/hour. Regression analysis was also used to examine whether variation in the proportion of ravens using lower sections of a tower was related to variation in total tower count.

Marking Ravens

One hundred and thirty raven nestlings (59 from natural substrate and 71 from tower nests) were marked during May and June to determine whether ravens fledged from nests on or adjacent to the line comprised part of the roosting population. We also wanted to determine when fledglings joined roosts and how far they would travel from their nests to do so. Ravens were fitted with either wrap-around (Kochert et al. 1983) or piercing (S. Platt and D. Runde pers. comms.) wing markers and colored leg-bands. Markers were made of 18-TXN vinyl-coated nylon (Cooley Inc., Anaheim, Calif.), and numbers were painted on using black-gloss vinyl screen ink (Naz Dar Co., Chicago, Ill.). Wing-markers were either red or blue and bore a single digit from 0 to 4. The color of the right wing-marker designated the marking year (blue=1984), and the color of the left wing-marker denoted the source of the bird (red=natural substrate nest; blue = tower nest). Numbers on wing-markers in combination identified the specific nest location. In addition, ravens were fitted with 1 color-anodized aluminum band on each leg. The left band was a butt-end band, and the right was a Fish and Wildlife Service numbered lock-on band. Five colors of bands were used; colors corresponded with numbers on wing-markers (0=silver, 1=yellow, 2=blue, 3=red, and 4=green).

Two attempts were made to spray roosting ravens with ink to identify foraging areas and examine interchange of ravens among roosts. Methods were patterned after those described by Siegfried (1971). The marking substance used was Sunsheen flexographic printer's ink (Sun Chemical Corp., Carlstead, N.J.); a non-toxic, quick-drying, alcohol-based compound. The spray delivery system was a series of Spray-1 full circle sprinkler heads (Nelson Irrigation Corp., Walla Walla, Wash.) distributed throughout the tower lattice. Sprinklers were attached to PVC pipe which led to a 113-l tank of ink solution charged to 180 psi with bottled nitrogen. A 122-m length of electrical fence wire was secured to the pressure release valve on the tank, and used to trigger the system. Spray attempts were made on relatively windless nights after ravens had been roosting for at least 3 hours.

During September, attempts were made to trap and mark ravens in the vicinity of the Initial Point Roost to identify foraging areas and examine interchange of ravens between roosts. A drop-in trap described by Stiehl (1978) was employed. We used 5-cm mesh poultry netting for trap walls, rather than the 2.5-cm mesh used by Stiehl (1978), due to problems with ravens repeatedly poking their bills through the holes in the mesh and abrading their heads. The larger mesh allowed ravens to continue this activity without injuring themselves. Two live ravens acquired as nestlings

and raised in captivity were used as decoys inside the trap; denatured beef entrails were used for bait.

Regurgitated raven pellets containing undigested portions of food were collected weekly beneath towers at 3 roosts (Initial Point, Wilson Creek, and Marsing Southwest) to examine whether changes in food habits were related to changes in roosting. Transects extending from the end of 1 crossarm to the end of the opposite crossarm were established beneath at least 1 tower at each of the 3 roosts. All pellets within 0.5 m of this transect were collected. Twenty-five pellets were randomly selected from each weekly collection for analysis. Fifteen of these pellets were examined superficially for the presence of Townsend ground squirrel (Spermophilus townsendii) and grasshopper (Orthoptera: Acrididae) remains. The 10 remaining pellets were analyzed in detail. Diet composition was assessed by recording the minimum number of individuals per taxon (Mollhagen et al. 1972) in each pellet.

Habitat Characterization

Fifty-five roost towers and 55 randomly selected towers not used for roosting (non-roost towers) in the study area were compared with regard to topographic characteristics, land use, and cultural developments. Specific variables examined were: length (km) of interstate highway, primary (gravelled or paved) road, secondary (dirt) road; length of distribution line (<69 kV) and transmission line (>69 kV) other than the 500 kV; amount (ha) of agricultural land, shrubland, and grassland; length of cliff (>15 m); and degree of topographic variation. These variables were assessed within a 1-km radius of towers using 1:30,000 aerial photographs, 1:24,000 topographic quadrangles, and PP&L plan and profile prints. The 500 kV line and its associated maintenance roads were excluded from analyses. Topographic variation around each tower was calculated as the difference in elevation between the lowest and highest points within the 1 km radius. The ratio of the differences between the highest point and the tower base, and the lowest point and the tower base was used as an index to the tower's relative topographic position. T-tests were used in these analyses. Chi-square tests were used to compare the frequency of other variables between roost and non-roost towers.

Raptor and raven nests were inventoried on and adjacent to the transmission line (Kochert et al. 1984, BLM unpubl. data). Distances from these nests to roost and non-roost towers were calculated to determine whether differences existed. Raptor species considered were golden eagles (Aquila chrysaetos) and buteos (Buteo sp.).

Noise Level Monitoring

Noise level readings were taken beneath towers at the Initial Point Roost once during June and once during July. Readings were taken between 1000 and 1300 on relatively windless days with clear skies. Readings were compared with contamination levels on a tower-by-tower basis to determine whether contamination affected the amount of noise produced by conductors. Kendall's rank correlation test was used for analysis.

RESULTS

Distribution of Roosts

Nine roosts were located on the line during 1984, however, not all were occupied simultaneously (Table 1). Seven of the 9 roosts were between miles 101-156 (Fig. 2). The average distance between these roosts was 9 km (range=2-24 km). The other 2 roosts were west of the study area. The number of occupied roosts increased as the season progressed. During March, only 4 roosts were occupied. But by July, 8 roosts were occupied. The number of occupied roosts dropped to 6 in September.

In April, raven roosts in the study area were at least 8 km apart and the mean distance between roosts was 18 km (range=8-29 km). By August, the number of roosts had increased from 3 to 5 in the study area while the expanse of roosts had nearly doubled. Consequently, the mean distance between adjacent roosts narrowed to 9 km (range=2-24 km).

Based on the number of ravens counted, there appeared to be some interchange of ravens between adjacent roosts (Table 2). As the number of ravens decreased at the Initial Point and Marsing Dump roosts, there were concomitant increases in numbers at the Swan Falls Road and Marsing Southwest roosts, respectively. Interchange between roosts was also evidenced by the sighting of a raven spray-marked at the Swan Falls Road Roost at the Initial Point Roost.

Size and Composition of Roosts

The Initial Point Roost was the largest roost on the transmission line, accounting for approximately 56% of the total roosting population on the line from April through August. Numbers of ravens using this roost varied from April through September (Fig. 3). Numbers gradually increased from early April until mid-June when a more rapid increase occurred; the number of roosting ravens doubled from mid-June to mid-July when a peak of 2103 ravens was observed. After this peak count, numbers declined. By late September, no ravens were roosting on the transmission line within 3 km of the Initial Point Roost.

Numbers of ravens roosting along the remainder of the transmission line followed the same basic trend observed at the Initial Point Roost (Fig. 4). Numbers sharply increased from spring through midsummer. Simultaneous counts ranged from 914 birds on 14 June to 2289 birds on 9 August. Thereafter, numbers declined. It is likely that this rapid increase in numbers in early summer was at least partially due to an influx of nesting ravens and their young. Fifty-three sightings of marked ravens at the Initial Point Roost confirmed that fledglings from both tower and natural substrate nests joined roosts at least by early July, and that they travelled up to 24 km to do so.

Use of the Initial Point Roost

Ravens showed affinities for certain sections of towers at the Initial Point Roost (Fig. 5). Over 80% of the ravens observed at the Initial Point Roost used the upper sections of towers. Ravens usually filled upper

Table 1. Raven roosts located on the Midpoint to Malin 500 kV transmission line during 1984.

Roost*	Location	Maximum Count	Date of Maximum Count	Period of Occupancy (mo)
Pleasant Valley (9)	101-103	144	9 August	June-August
Initial Point (8)	107-114	2103	22 July	March-September
Swan Falls Road (7)	115-117	322	25 September	March-September
Bernard Ditch (6)	125-126	7	12 July	June-August
Wilson Creek (5)	131-132	319	20 September	April-September
Marsing Dump (4)	148-149	613	9 August	August-September
Marsing Southwest (3)	154-156	477	19 April	March-September
Wagontire (2)	321-322	148	2 July	March-September
Christmas Valley (1)	342	63	3 July	July

* numbers in parentheses correspond to locations plotted on Fig. 2.

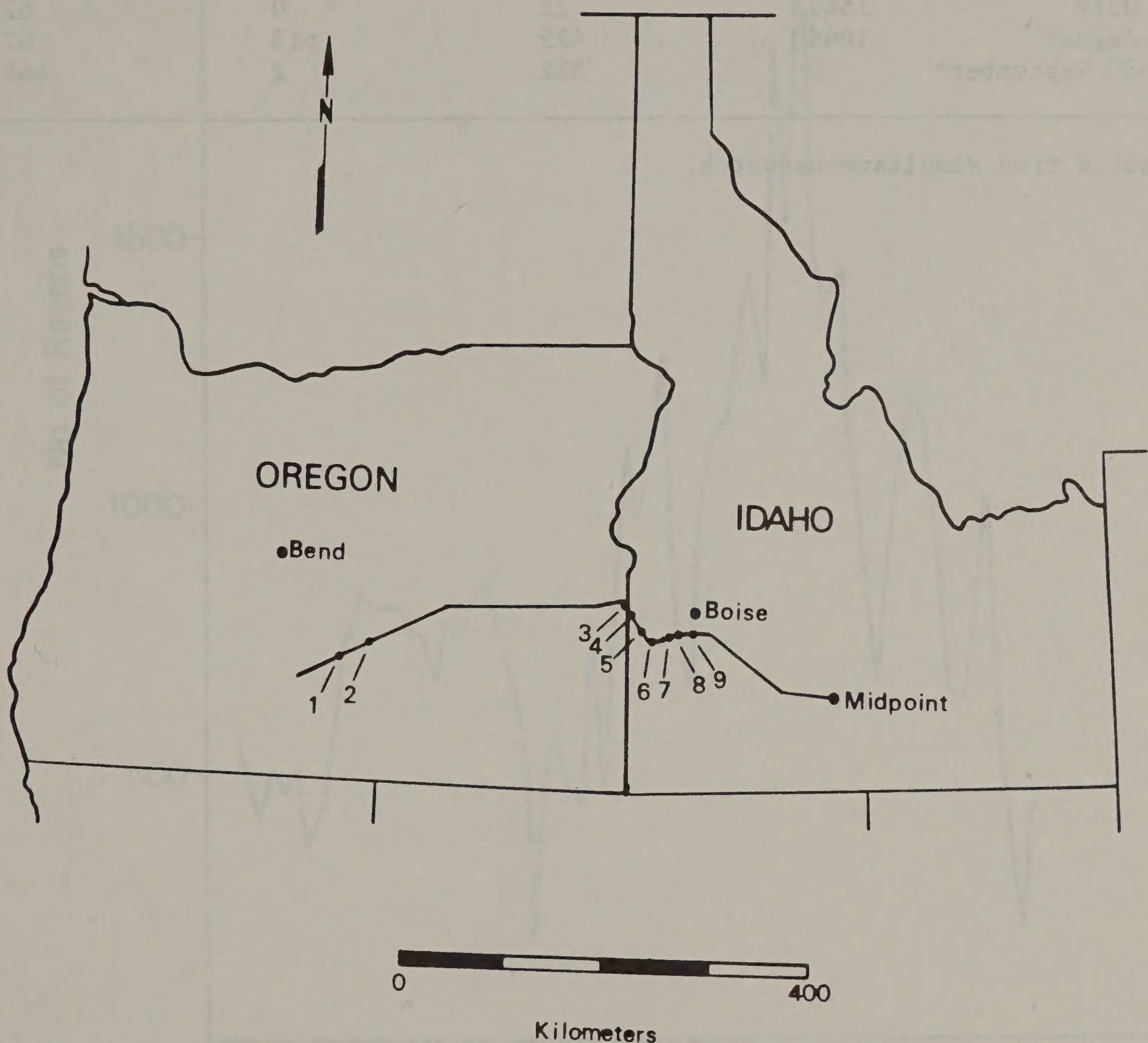

Figure 2. Raven roosts located on the Midpoint to Malin 500 kV transmission line during 1984 (numbers correspond to Table 1).

Table 2. Numbers of ravens counted during simultaneous watches at the Initial Point, Swan Falls Road, Marsing Dump, and Marsing Southwest roosts.

Date	Initial Point	Swan Falls Road	Marsing Dump	Marsing Southwest
19 April	299	144	0	477
13 May	685	37	0	420
14 June	472	36	0	170
12 July	1540	22	0	62
09 August	1046	425	613	67
25-30 September*	0	332	2	468

* not a true simultaneous watch.

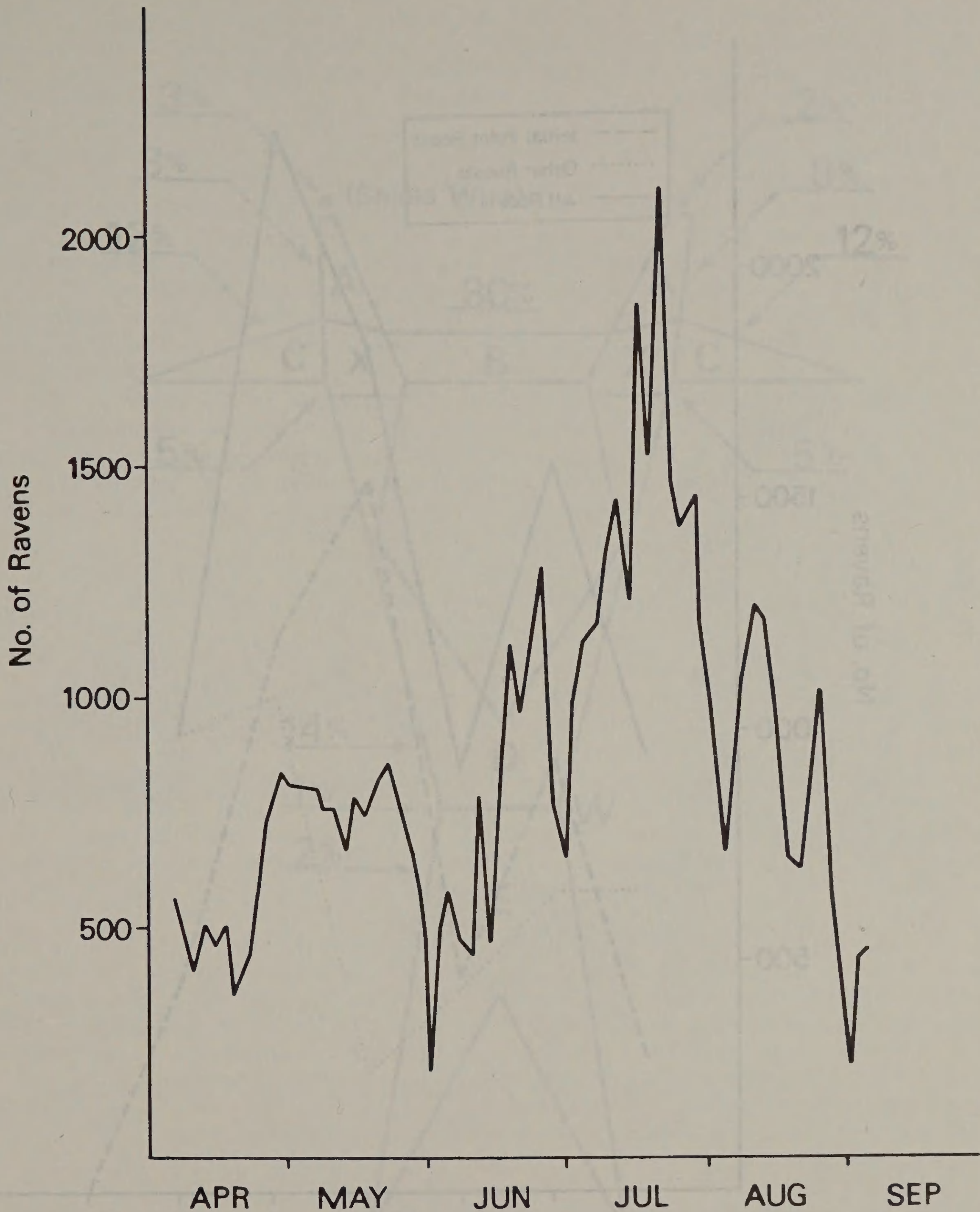

Figure 3. Numbers of ravens roosting at the Initial Point Roost, April-September 1984.

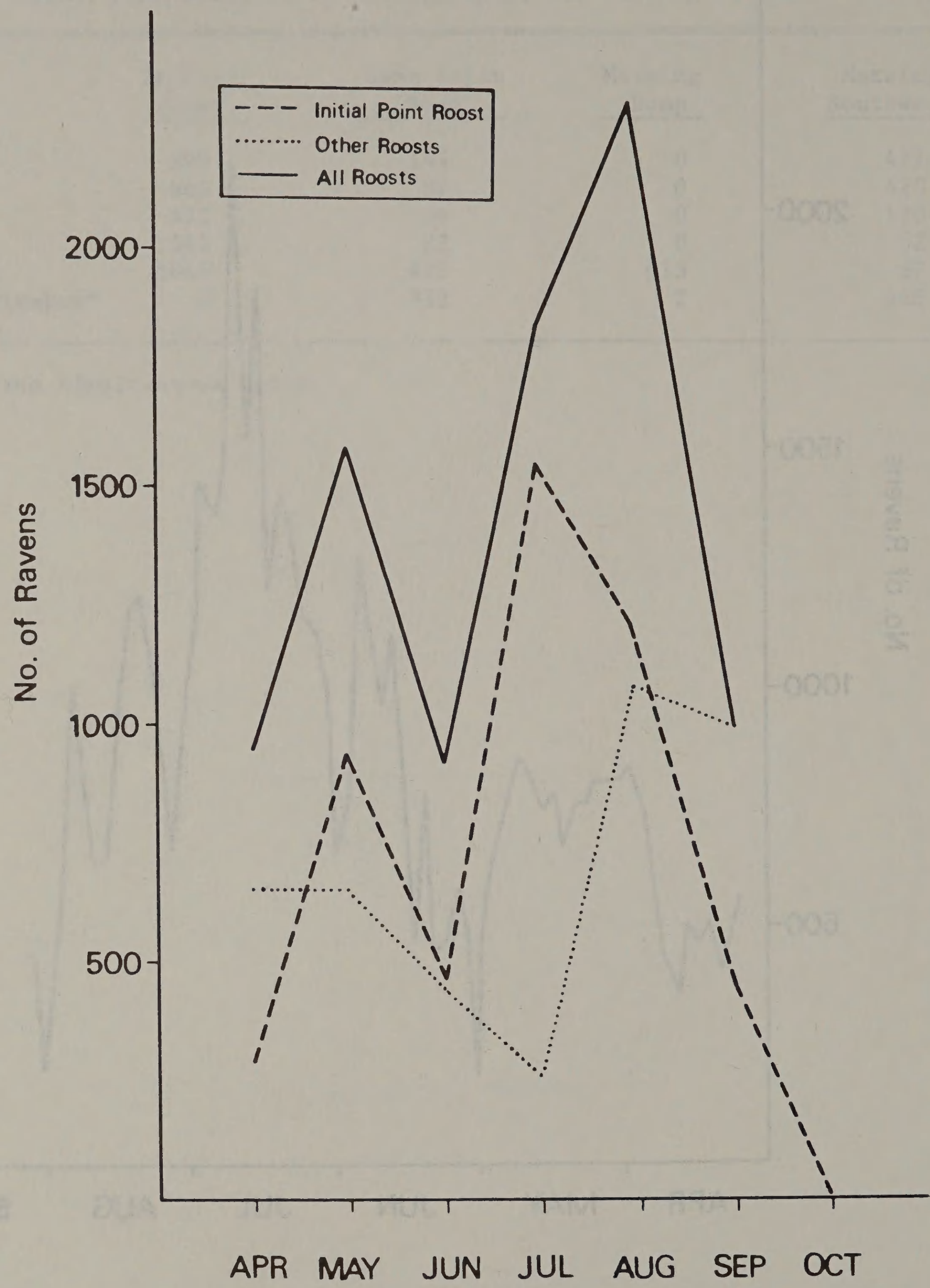

Figure 4. Numbers of ravens counted during simultaneous roost watches, April-September 1984.

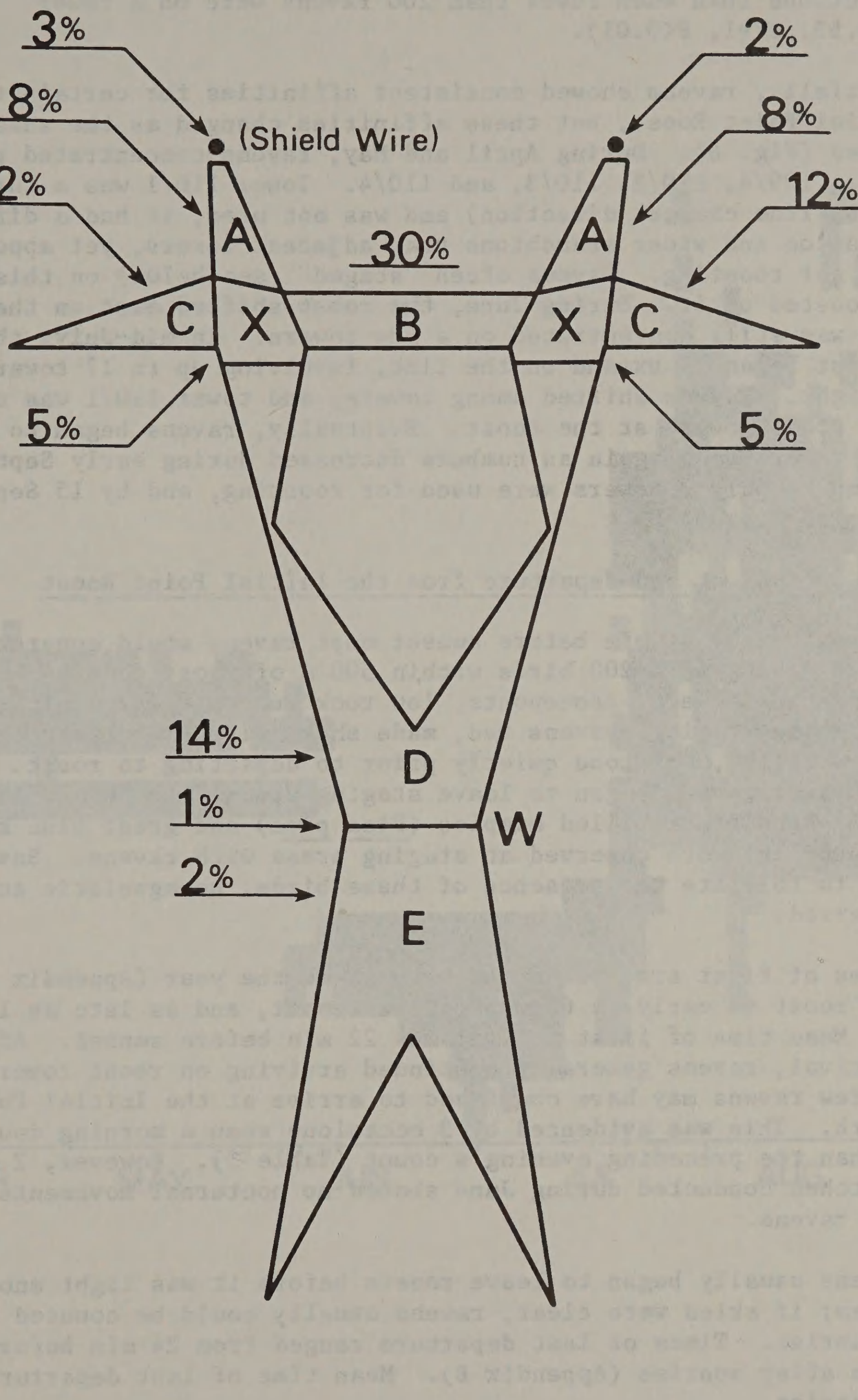

Figure 5. Use of tower sections by ravens roosting at the Initial Point Roost, April-September 1984.

sections of towers before using lower sections. When more than 200 ravens roosted on a tower, a relatively higher proportion of ravens roosted on the lower sections than when fewer than 200 ravens were on a tower (X^2=3697.53, df=1, P<0.01).

Initially, ravens showed consistent affinities for certain towers at the Initial Point Roost, but these affinities changed as the season progressed (Fig. 6). During April and May, ravens concentrated primarily on 4 towers: 109/4, 110/2, 110/3, and 110/4. Tower 110/1 was a turn tower (where the line changes direction) and was not used; it had a different configuration and wider stanchions than adjacent towers, yet appeared suitable for roosting. Ravens often "staged" (see below) on this tower, but seldom roosted on it. During June, the roost shifted east on the line, yet roosting was still concentrated on a few towers. In mid-July, the Initial Point Roost began to expand on the line, involving up to 17 towers on a single night. Ravens shifted among towers, and tower 110/1 was used as often as other towers at the roost. Eventually, ravens began to congregate on fewer towers once again as numbers decreased during early September. On 11 September, only 3 towers were used for roosting, and by 15 September the roost was evacuated.

Times of arrival at and departure from the Initial Point Roost

Approximately 40 min before sunset most ravens would congregate or "stage" in groups of 4-200 birds within 500 m of roost towers. Ravens staged on other towers, fenceposts, low rock outcrops (<2 m high), and the ground. While staging, ravens fed, made short flights, chased one another, walked, vocalized, or stood quietly prior to departing to roost. Generally, once the first ravens began to leave staging areas, the others soon followed. Both black-billed magpies (*Pica pica*) and great blue herons (*Ardea herodias*) were observed at staging areas with ravens. Ravens appeared to tolerate the presence of these birds; no agonistic encounters were observed.

Times of first arrival varied throughout the year (Appendix A). Ravens began to roost as early as 60 min before sunset, and as late as 1 min after sunset. Mean time of first arrival was 22 min before sunset. After the first arrival, ravens generally continued arriving on roost towers for 20-30 min. A few ravens may have continued to arrive at the Initial Point Roost after dark. This was evidenced by 3 occasions when a morning count was larger than the preceding evening's count (Table 3). However, 2 all-night roost watches conducted during June showed no nocturnal movements by roosting ravens.

Ravens usually began to leave roosts before it was light enough to count them; if skies were clear, ravens usually could be counted by 35 min before sunrise. Times of last departure ranged from 24 min before sunrise to 55 min after sunrise (Appendix B). Mean time of last departure was 6 min before sunrise.

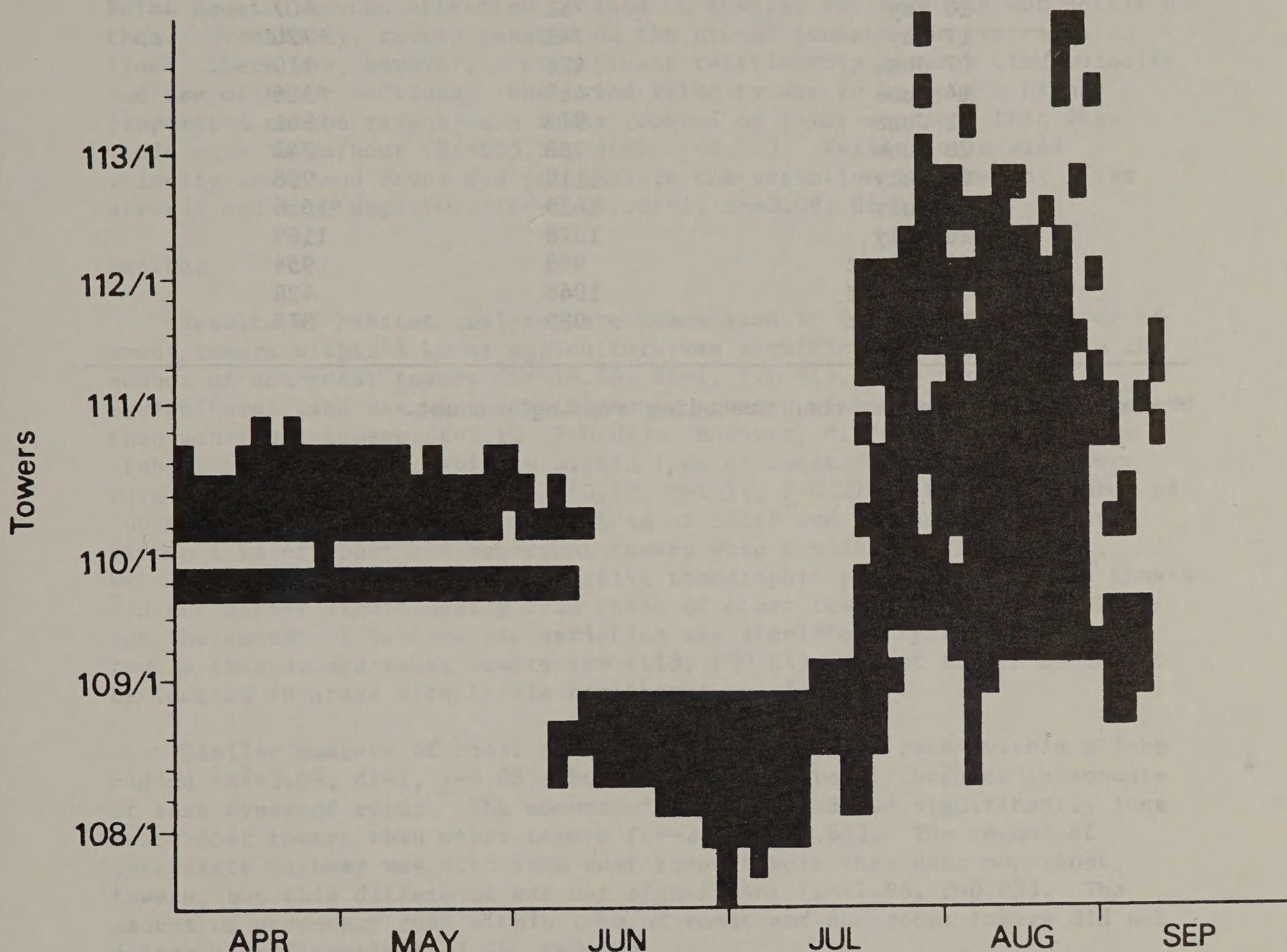

Figure 6. Use of towers by ravens at the Initial Point Roost during 1984 (shaded blocks represent occupied towers).

Table 3. Maximum numbers of ravens counted during morning and evening roost watches at the Initial Point Roost, April-September 1984.

Date of Evening Watch	Evening Count	Morning Count
12 April	507	339
19 April	358	226
26 April	727	597
10 May	761	407
17 May	742	*770
07 June	476	119
14 June	469	*516
21 June	973	961
28 June	768	745
05 July	1119	998
12 July	1429	*1556
26 July	1378	1169
02 August	993	954
09 August	1046	428
16 August	985	373

* morning count greater than preceding evening's count.

Factors Influencing Roosting

Weather

An insignificant amount of the variation in total roost counts could be explained by variation in wind velocity (r^2=0.02, df=1), cloud cover (r^2=0.01, df=1), or temperature (r^2=0.06, df=1). However, on a night when wind exceeded 48 km/hour, no ravens roosted on towers at the Initial Point Roost. Ravens attempted to land on towers, but they did not settle on them. Eventually, ravens roosted on the ground beneath the transmission line. There was, however, a significant relationship between wind velocity and use of tower sections. When wind velocity was >8 km/hour a higher proportion of the ravens on a tower roosted on lower sections than when winds were <8 km/hour (X^2=853.58, df=1, $\underline{P}$<0.01). Variation in wind velocity and cloud cover did not explain the variation in times of first arrival and last departure (r^2=0.01, df=1; r^2=0.08, df=1).

Habitat

Results of habitat analyses are summarized in Table 4. The number of roost towers within 1 km of agriculture was significantly greater than the number of non-roost towers (X^2=14.86, df=1, $\underline{P}$<0.01). The amount of agricultural land was also significantly greater within 1 km of roost towers than non-roost towers (t=2.10, $\underline{P}$=0.04). However, differences in amounts ofshrub and grassland habitats within 1 km of roost and non-roost towers were not significant (t=-1.58, $\underline{P}$=0.12; t=1.11, $\underline{P}$=0.27). Both the number of roost and non-roost towers within 1 km of cliff and the amount of cliff within 1 km of roost and non-roost towers were similar (X^2=1.93, df=1, $\underline{P}$=0.17; t=1.39, $\underline{P}$=0.17). The relative topographic positions of roost towers did not differ significantly from those of other towers (t=1.18, $\underline{P}$=0.24), but the amount of topographic variation was significantly less at roost towers than at non-roost towers (t=-4.13, $\underline{P}$<0.01). Roost towers tended to be located in areas with little topographic variation.

Similar numbers of roost and non-roost towers had roads within a 1-km radius (X^2=3.09, df=1, $\underline{P}$=0.08); however, there were differences in amounts of some types of roads. The amount of primary road was significantly less near roost towers than other towers (t=-2.15, $\underline{P}$=0.03). The amount of interstate highway was also less near roost towers than near non-roost towers, but this difference was not significant (t=-1.96, $\underline{P}$=0.05). The amount of secondary road within 1 km of roost and non-roost towers did not differ significantly (t=1.79, $\underline{P}$=0.08).

The presence and amount of other power lines differed significantly between roost and non-roost towers. Fewer roost towers than non-roost towers occurred near other power lines (X^2=6.02, df=1, $\underline{P}$=0.01). Other transmission lines seemed to account for this difference. While the amounts of distribution line within 1 km of each tower type were nearly equal (t=-0.29, $\underline{P}$=0.77), the amount of transmission line was significantly less near roost than near non-roost towers (t=-3.09, $\underline{P}$<0.01). Similar numbers of roost and non-roost towers had buildings within 1 km (X^2=0.69, df=1, $\underline{P}$=0.41).

Table 4. Results of statistical analyses comparing vegetative, topographic, and cultural features within 1 km of roost towers and towers not used for roosting.

Variable	T-value	P
Hectares of agricultural land	2.10	.038*
Hectares of grassland	1.11	.270
Hectares of shrub	-1.58	.118
Length of cliff	-1.39	.168
Relief ratio	1.18	.240
Total relief	-4.13	<.001*
Length of interstate highway	-1.96	.053
Length of primary road	-2.15	.034*
Length of secondary road	1.79	.076
Length of transmission line	-3.09	.003*
Length of distribution line	-0.29	.772

Variable	Chi-square value	P
Presence of agricultural land	14.86	.001*
Presence of buildings	0.69	.406
Presence of cliff	1.93	.165
Frequency of roads	3.09	.079
Frequency of other power lines	6.02	.014*

* Difference significant at $\underline{P}<0.05$ level.

Food Habits

Four hundred and twenty-three pellets collected from May through August were analyzed in detail (Table 5). Vegetation, insect, and small mammal remains were the most frequently encountered items in pellets. Vegetation remains were found in 415 (98%) of the pellets, but vegetation seldom comprised an entire pellet. Vegetation may have been ingested incidentally or as food. Grasshoppers and beetles (Coleoptera) comprised the majority of the insects identified; montane voles (Microtus montanus) and Townsend ground squirrels comprised the majority of identifiable small mammal remains. A large portion of both insect and small mammal remains could not be identified; therefore, actual proportions of insects and small mammals are not available.

The percent of pellets containing each of these 3 main pellet components varied temporally (Fig. 7). Percent of pellets containing vegetation varied little, whereas percent of pellets containing insect and small mammal remains varied considerably during the sampling period. Mammals decreased in occurrence from May to September. Mammmals occurred in 79% of the pellets during May then decreased in occurrence to 64% during August. On the other hand, frequency of insects in pellets increased gradually from May through August. In May, insects occurred in 64 of 102 pellets (63%); they steadily increased in frequency to occur in 93 of 100 pellets (93%) during August. Grasshoppers comprised at least 46% of the total number of insects counted in pellets and increased dramatically in frequency from May to August. This may explain the increase in frequency of all insects during the sampling period.

Raven and Raptor Nesting

During 1984, 55 raven nests were located on the entire line (Kochert et al. 1984). Seventeen (31%) of these nests were located in the study area. Nest density was 0.21 nests per km in the study area, compared to 0.07 nests per km over the remainder of the line (BLM unpublished data). Thirteen of these 17 (76%) nests were located within 5 km of a roost tower. The raven nest closest to a roost was on tower 111/1, within the boundaries of the Initial Point Roost. During the time this nest was occupied, other ravens roosted on towers adjacent to 111/1 but not on it. After the young from this nest fledged, however, other ravens roosted on this tower.

One golden eagle and 6 buteo [1 red-tailed hawk (Buteo jamaicensis) and 5 ferruginous hawks (Buteo regalis)] nests were located on transmission towers in the study area during 1984 (Kochert et al. 1984). Two buteo pairs (1 red-tailed hawk and 1 ferruginous hawk) nested on towers within 1 km of a roost tower (BLM unpublished data). Golden eagle nests (both natural substrate and tower nests) were located farther from raven roost towers than were buteo nests. The closest golden eagle nest was a natural substrate nest located 4.1 km from a roost tower, while the closest buteo nest was located on a tower 0.4 km (1 tower span) from a roost tower (Kochert et al. 1984). The nearest buteo nest was a ferruginous hawk nest on tower 109/2, within the boundaries of the Initial Point Roost. As in the case of the raven nest within this roost, ravens initially roosted on towers adjacent to 109/2 but not on the tower itself; however, soon after the young hawks fledged ravens began to use this tower. No agonistic encounters were

Table 5. Food items identified in 423 raven pellets collected from May-August 1984.

Food item	Minimum no. of individuals	No. of pellets containing item	Percent pellets containing item
MAMMALS			
Microtus montanus	160	106	25
Spermophilus townsendi	39	34	8
Lepus spp.	9	9	2
Thomomys spp.	9	9	2
Peromyscus maniculatus	2	2	trace
Ammospermophilus leucurus	2	2	trace
Marmota flaviventris	1	1	trace
Unidentified mammals	217	216	51
Total mammals	437	317	75
INSECTS			
Acrididae	389	203	48
Coleoptera	297	148	35
Unidentified insects	157	152	36
Total insects	843	347	82
VEGETATION	no count	415	98
EGG SHELL	55	55	13

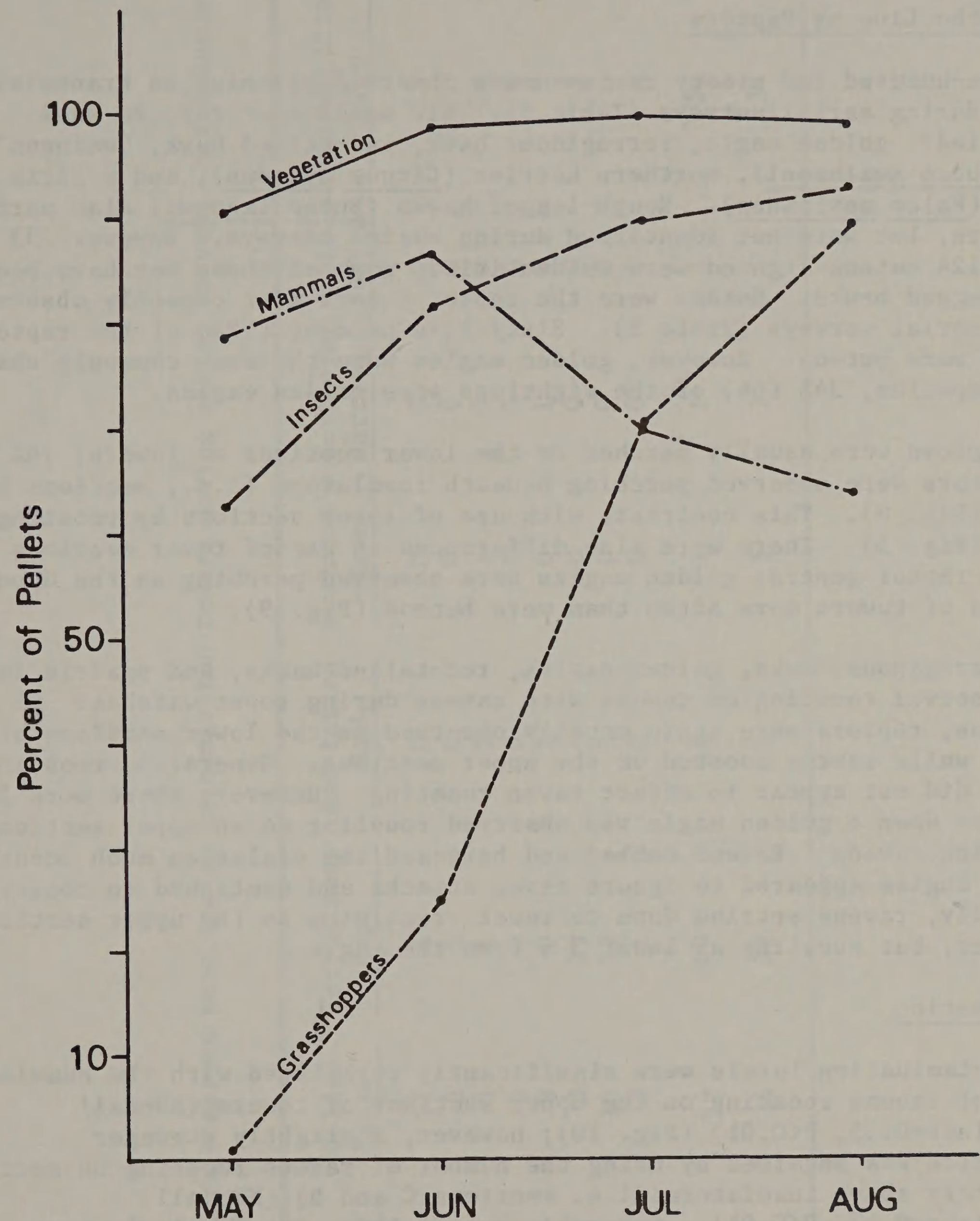

Figure 7. Seasonal shifts in percent of pellets containing major food items, May-August 1984 (Insects includes grasshoppers.).

observed between the nesting hawks and ravens. Circumstantial evidence suggests that the fledged hawks and their parents roosted on towers at the Initial Point Roost; immature and adult ferruginous hawks were observed roosting on towers with ravens after these young had fledged.

Use of the Line by Raptors

One-hundred and ninety raptors were observed perching on transmission towers during aerial surveys (Table 6). Six species of raptors were identified: golden eagle, ferruginous hawk, red-tailed hawk, Swainson's hawk (*Buteo swainsoni*), northern harrier (*Circus cyaneus*), and prairie falcon (*Falco mexicanus*). Rough-legged hawks (*Buteo lagopus*) also perched on towers, but were not identified during aerial surveys. However, 53 (43%) of the 124 buteos sighted were unidentified; some of these may have been rough-legged hawks. Buteos were the raptor genera most commonly observed during aerial surveys (Table 6). Sixty-five percent (124) of the raptors sighted were buteos. However, golden eagles were the most commonly observed raptor species; 34% (64) of the sightings were golden eagles.

Raptors were usually perched on the lower sections of towers; 74% of the raptors were observed perching beneath insulators (i.e., sections D, W, and E) (Fig. 8). This contrasts with use of tower sections by roosting ravens (Fig. 5). There were also differences in use of tower sections between raptor genera; golden eagles were observed perching on the upper sections of towers more often than were buteos (Fig. 9).

Ferruginous hawks, golden eagles, red-tailed hawks, and prairie falcons were observed roosting on towers with ravens during roost watches. On these occasions, raptors were again usually observed on the lower sections of towers, while ravens roosted on the upper sections. Generally, roosting raptors did not appear to affect raven roosting. However, there were 2 occasions when a golden eagle was observed roosting on an upper section of a tower with ravens. Ravens mobbed and harassed the eagles on each occasion, but the eagles appeared to ignore raven attacks and continued to roost. Eventually, ravens settled down to roost, remaining on the upper sections of the tower, but roosting at least 3 m from the eagle.

Contamination

Contamination levels were significantly correlated with the cumulative number of ravens roosting on the upper sections of towers (Kendall coefficient=0.55, $P<0.01$) (Fig. 10); however, a slightly stronger correlation was obtained by using the number of ravens roosting on sections immediately above insulators (i.e. sections C and B) (Kendall coefficient=0.57, $P<0.01$). Generally once a tower was regularly roosted on by ravens, light contamination accumulated within 1 week. However, a minimum of 6 weeks was required to visibly detect a decrease in contamination whereby one might infer a roost had decreased in size. For example, the Initial Point Roost was evacuated by 15 September, but by 28 October contamination levels on roost towers had decreased only slightly (Table 7).

Table 6. Raptors observed perching on transmission towers during aerial surveys, March-August 1984.

Date of Survey	Golden Eagle	Ferruginous Hawk	Red-tailed Hawk	Swainson's Hawk	Northern Harrier	Prairie Falcon	Unidentified Buteo
12 March	18	4	0	0	0	0	12
26 March	3	0	0	0	0	0	3
11 April	8	6	2	1	0	0	10
27 April	5	4	0	0	0	1	8
23 May	9	9	1	0	1	0	9
18 June	9	13	4	0	0	0	9
16 July	10	23	3	0	0	0	0
13 August	2	1	0	0	0	0	2
TOTAL	64	60	10	1	1	1	53
% of TOTAL	34	32	5	1	1	1	28

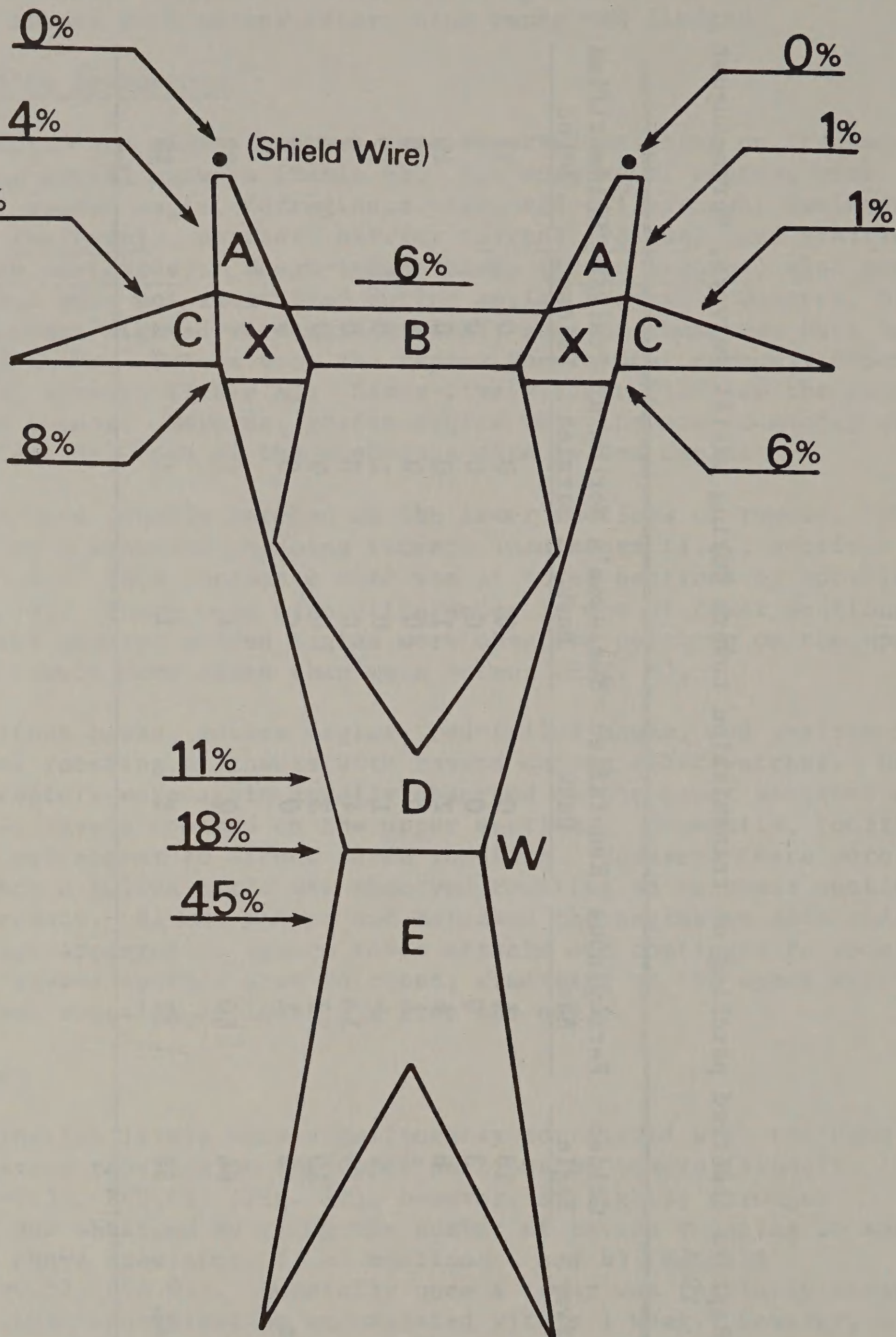

Figure 8. Use of tower sections by raptors observed during aerial surveys, April-August 1984.

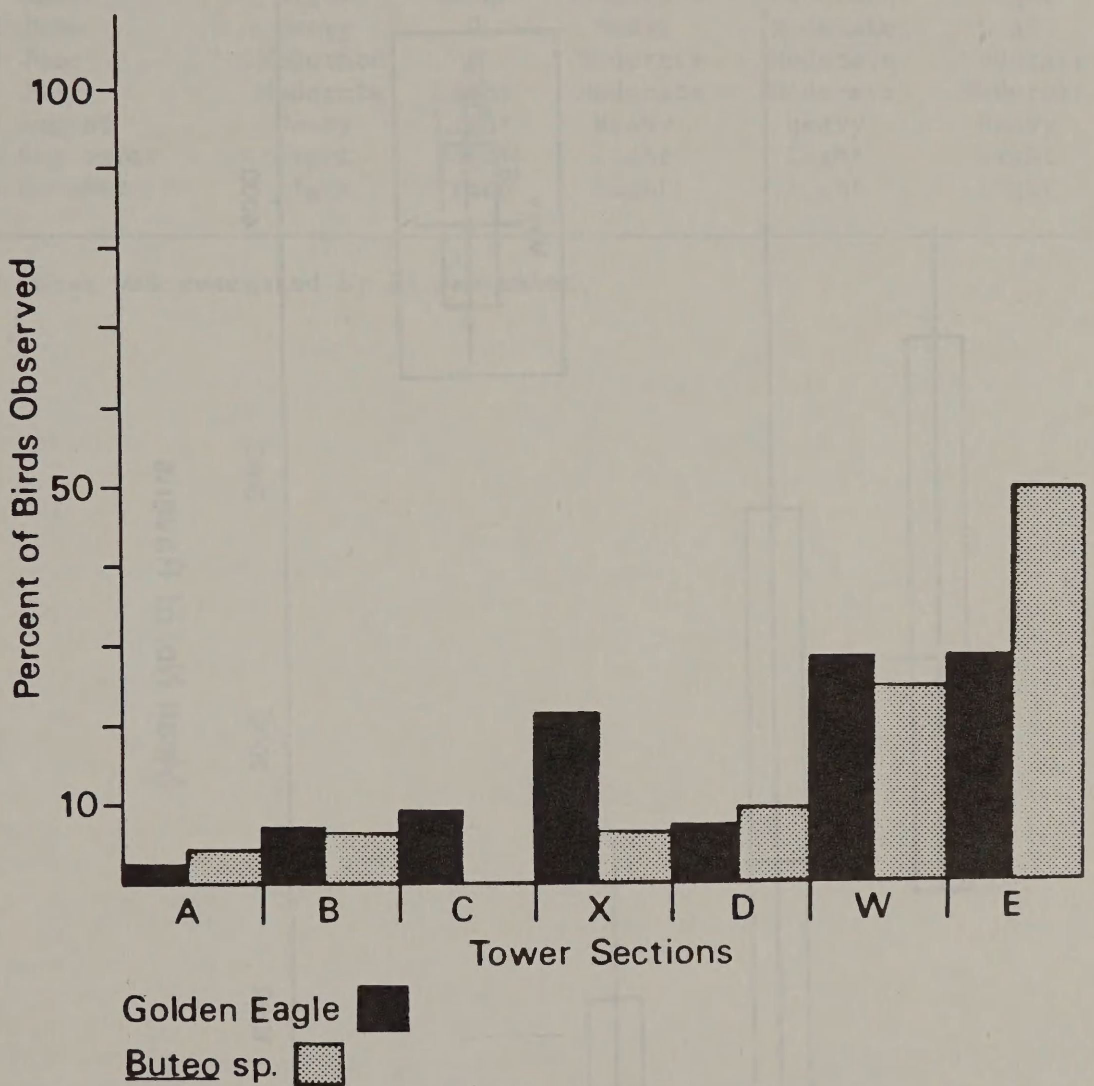

Figure 9. Use of tower sections by golden eagles and buteos observed during aerial surveys, April-September 1984.

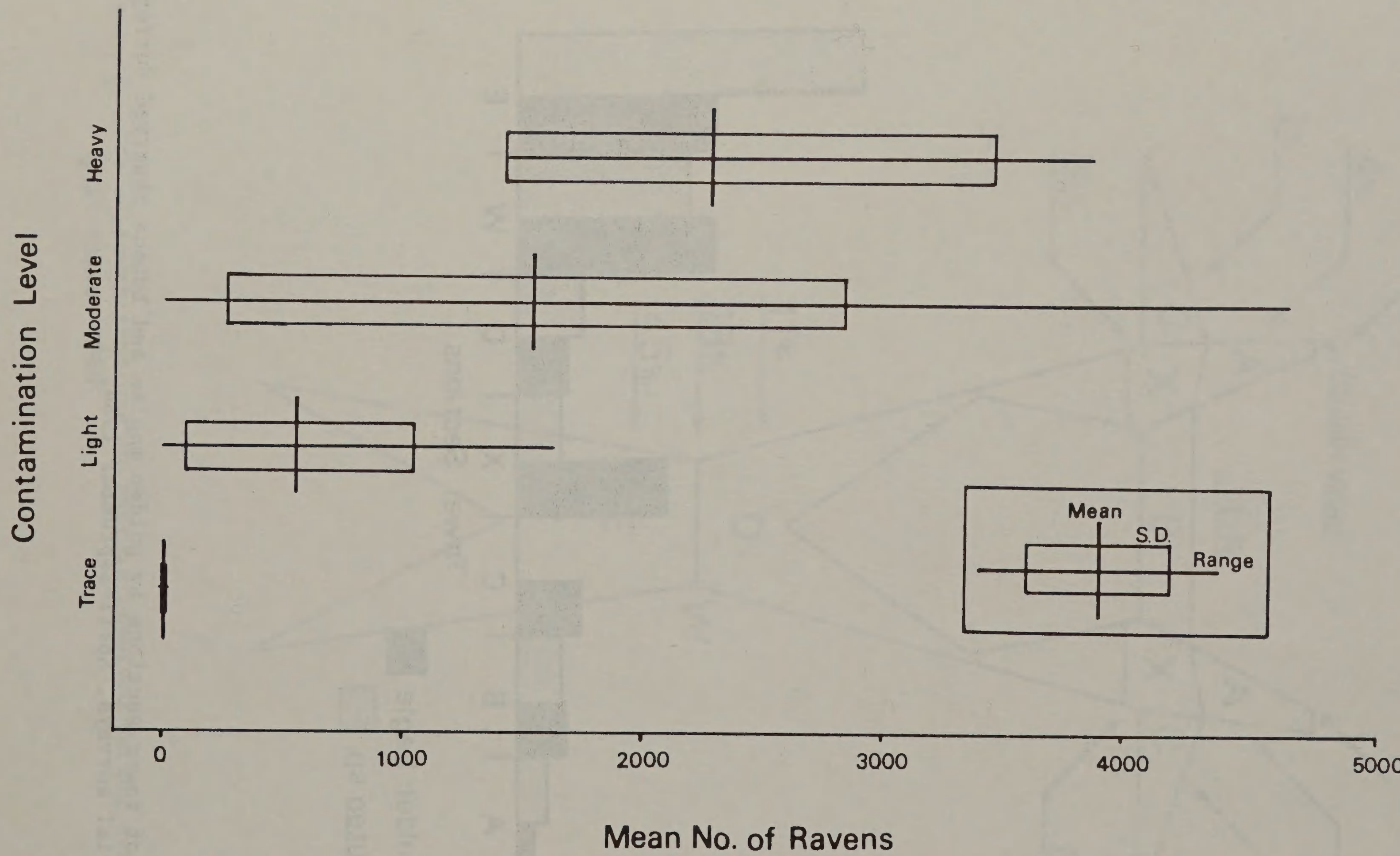

Figure 10. Contamination levels compared to the cumulative number of ravens roosting on towers at the Initial Point Roost between ground surveys.

Table 7. Contamination levels at selected towers at the Initial Point Roost, April-September 1984.

Date	Tower 109/4	110/1	110/2	110/3	110/4
30 April	Light	Trace	Moderate	Moderate	Light
5 June	Heavy	0	Heavy	Moderate	Light
25 June	Moderate	0	Moderate	Moderate	Moderate
24 July	Moderate	Light	Moderate	Moderate	Moderate
20 August	Heavy	Light	Heavy	Heavy	Heavy
*24 September	Light	Light	Light	Light	Light
28 October	Light	Trace	Light	Light	Light

* This roost was evacuated by 15 September.

Noise Level Monitoring

Noise level readings were significantly correlated with levels of contamination on towers at the Initial Point Roost (Kendall coefficient=0.51, $\underline{P}<0.01$). As contamination increased on insulators, there was a concomitant increase in the amount of noise produced by conductors. There was no evidence, however, that increased noise caused ravens to abandon heavily-contaminated towers.

Marking Roosting Ravens

Spraying

The first attempt to mark roosting ravens with ink was made at tower 115/4 on 14 July. Approximately 30 ravens roosted on the tower that evening. The delivery system performed as anticipated, but few birds were adequately sprayed. A delay between the time when the system was activated and the time when ink reached sprinkler heads was the most probable cause of low marking success. While hoses were filling with ink, there was a considerable amount of noise produced by nitrogen filling the pressure tank and air rushing through the spray heads. This probably disturbed the ravens and caused most of them to leave the tower before ink was delivered. To alleviate this problem the hose leading to the spray heads was pre-filled with ink, and spraying was attempted again. Ravens, however, did not roost on this tower during subsequent evenings. On 30 July the spray apparatus was moved to tower 155/2. Ravens had roosted on 155/2 the preceding night, but no birds roosted on this tower on 30 July or subsequent nights. Spraying attempts were then terminated due to concern that these attempts and the presence of the spray apparatus were disrupting ravens' tower selections, and hence compromising other study objectives.

Trapping

No ravens were captured during attempts to trap them. This may have been due to an abundance of natural food that reduced the attractiveness of bait. In addition, the denatured beef entrails used for bait were marbled with bright green coloration due to charcoal used in the denaturing process. Therefore, the bait may have appeared unattractive to ravens.

Other Roosts

Historical Roosts

A roost located on a low (<10 m) rock outcrop approximately 5 km northwest of the Initial Point Roost and 3 km north of the Swan Falls Road Roost was observed during 1969 (N. Nydegger pers. comm.). Evidently, 75-100 ravens roosted there at that time. However, no ravens were observed roosting there during 1984, nor were pellets or whitewash observed when the roost was inspected. During 1979, 400-500 ravens were observed roosting on an Idaho Power Company (IPC) power line where it presently intersects the 500 kV transmission line at the Swan Falls Road Roost (J. Doremus pers. comm.). Following the spray attempts at the Swan Falls Road Roost, ravens were observed roosting at this location on the IPC power line. Three hundred to 500 ravens have day-roosted for at least the past 5 years in a

group of trees approximately 0.8 km north of mile 107 (the east boundary of the Initial Point Roost) (N. Stimpson pers. comm.). Eight hundred to 1000 ravens were observed day-roosting in these trees, on fenceposts, and on the ground on 10 July 1984. It is not known whether ravens ever night-roosted at this site.

Natural Substrate Roosts

M. Mulrooney (pers. comm.) reported 2 natural substrate roosts in the vicinity of the transmission line during 1984. A roost of at least 100 ravens was located on rimrock approximately 1.6 km north of mile 176. The second roost also involved at least 100 ravens, and was located in a group of trees approximately 16 km northwest of mile 158.

DISCUSSION

The roosting situation on the Midpoint to Malin 500 kV transmission line is unique. Ravens are more commonly known to roost on natural substrates; this is the first record of a raven communal roost on power transmission structures. The roosts are also unusual in that they are occupied during spring-summer. The raven roosting concentration at the Initial Point Roost is also the largest ever recorded. The largest concentration previously recorded occurred in Alaska and involved 800-900 ravens (Brown 1974).

Although the size, expanse, and locations of roosts varied, trends in these aspects of roosting could be observed. Seasonal variation in size of the Initial Point Roost was similar to 1983 (Steenhof 1983). In both years, numbers of ravens increased from March until mid-July then began to decline. The roost was evacuated during the fall in both 1983 and 1984. In addition, the largest roost occurred in the same general area during both years: miles 103-105 in 1983 and 107-114 in 1984.

The concentration of roosts between miles 101-156 emphasizes the need to examine differences between used and unused segments of the line in greater detail to determine what factors influence roost distribution. Kochert et al. (1984) observed the highest concentration of raptor and raven nests between miles 1-153. They noted that this section of the line closely follows the Snake River plain which is characterized by relatively flat terrain and deep, fertile soils. At mile 157, the line enters more rolling topography as it continues west while the Snake River turns north. Kochert et al. (1984) suggested that differences in soils and topography between the eastern and western sections of the line might result in different prey densities which could influence nest site selection. Differences in prey densities could influence roost site selection in a similar manner. Communal roosts of many species are often associated with abundant food sources (Waian and Stendall 1970, Rowley 1971, Ward and Zahavi 1973, Keister and Anthony 1983). Rowley (1971) observed that a population of Australian ravens (Corvus coronoides) changed roosts every time they shifted to a new foraging area. Results of pellet analysis in this study suggest that farmland may have been a common foraging habitat for ravens. Wheat and barley were frequently found in pellets. Montane voles, the small mammal most frequently identified in raven pellets, are commonly associated with

farmland (E. Yensen pers. comm.). Ravens were observed feeding in farmland in the vicinity of the Initial Point Roost. Roost selection may have been influenced by proximity to agriculture. Roost towers were located within 1 km of farmland significantly more often than were non-roost towers.

On a finer scale, changes in specific towers used within a roost may have been due to relatively minor changes in food distribution. Rowley (1971) observed frequent shifts in roost locations of Australian ravens associated with relatively minor changes in foraging areas. However, more information on raven foraging ecology accompanied by more detailed habitat analyses are needed to elucidate these relationships.

Numbers of ravens at roosts may have also been associated with local food availability. Rowley (1971) attributed seasonal and annual fluctuations in roost size to patterns of agriculture and food availability. Pellet analyses in this study indicate ravens fed extensively on grasshoppers from July through August 1984. Grasshoppers were considered the dietary staple of ravens during the summer (July-September) in eastern Oregon (Stiehl 1978). Grasshoppers are generally most abundant in southwestern Idaho from July through August, declining as colder temperatures and rains arrive during late summer or early fall (C. Baker pers. comm.). Raven numbers exhibited a similar trend; peak numbers of grasshoppers and ravens roughly coincided.

Roosting was also affected by human activities. During June, cameramen attempting to photograph ravens at the Marsing Southwest Roost parked their vehicle approximately 200 m from the commonly used roost tower. That night, ravens roosted on an adjacent tower approximately 600 m from the vehicle. However, ravens returned to the original roost tower on subsequent nights. Spray attempts at the Swan Falls Road and Marsing Southwest roosts also temporarily displaced roosting ravens. After the spraying attempt at the Swan Falls Road Roost, ravens began roosting on a 138 kV line which intersects the 500 kV line at mile 116. By August, however, all ravens had returned to the 500 kV line to roost.

Nesting raptors and ravens did not appear to deter ravens from roosting. Occupied buteo and raven nests were located on towers immediately adjacent to occupied roost towers. However, golden eagle nests were not found within 4.1 km of any raven roost. This may have been due to social interaction or differences in habitat requirements of nesting golden eagles, and nesting buteos and ravens. However, there were too few golden eagle nests on and near the line during 1984 to adequately investigate these possibilities. Raptor roosting also did not appear to discourage ravens from roosting on towers, although golden eagles temporarily disrupted raven roosting when they landed on the upper sections of towers. When raptors roosted on lower tower sections, raven roosting did not appear to be affected.

Ravens roosted consistently on the upper sections of towers, but they were not always evenly distributed laterally across these sections. This made it difficult to classify towers into contamination categories. When relatively few ravens roosted on a tower, they would often concentrate over 1 phase of insulators, causing heavy contamination on that phase without a trace of contamination on adjacent phases. There was no contamination

category to describe such a situation. In the future, contamination should be described on a phase-by-phase basis.

MANAGEMENT IMPLICATIONS

Findings from this year's research indicate the potential for a largescale contamination problem on the Midpoint to Malin 500 kV transmission line. Roosting was not confined to 1 specific location, but involved 9 separate segments of the line encompassing at least 63 towers. Up to 17 adjacent towers were used simultaneously at the largest roost. Collectively, roosts were used by at least 2,200 ravens. The largest roost was occupied by over 2,100 ravens on a single night.

Besides the potential for a widespread contamination problem, patterns of roosting present difficulties in attempting to control contamination. Ravens tended to roost on the upper sections of towers; over 80% of the ravens observed roosted above insulators. In addition, although roosting was concentrated on upper tower sections, ravens were not always evenly distributed laterally across these sections. Consequently, even relatively small numbers of ravens could pose a contamination problem by concentrating in a particular area, thus producing heavy contamination on some, but not all, insulators. Locations and sizes of roosts and periods of use were also inconsistent. The largest roost shifted west on the line 6-13 km from 1983 to 1984. Four roosting areas were identified on the line during April 1984, but by September, 5 more roosts had formed and 2 of these had subsequently been abandoned. Use of specific towers within these roosting areas also varied. Four towers were used for roosting at the Initial Point Roost during April, but by September up to 17 towers were involved in this roost. The numbers of ravens roosting on the line varied markedly over the course of the year. From 72 to 2103 ravens roosted at the Initial Point Roost during 1984. The length of time which roosts were occupied also varied considerably. The Bernard Ditch Roost was occupied for only 1 month, while the Marsing Southwest Roost was occupied year-round.

Suggestions to eradicate roosting and nesting ravens on the line can be rejected as a violation of federal and state laws. Extremely adverse publicity would be generated by proposal of such a program. Legal and public relations restraints aside, it is doubtful that an eradication program would be feasible. The composition of the roosting population is largely unknown and could involve large numbers of transient ravens. If this were the case, ravens removed from the population would quickly be replaced by others. Furthermore, sightings of marked ravens have shown that young from both tower and natural substrate nests at least 24 km away moved to roosts soon after fledging.

Certain approaches to discouraging ravens from roosting on the line appear to have little chance of success. Ravens were only temporarily displaced from roost towers by disturbances such as spray attempts and the presence of a vehicle within 200 m of a roost tower. Furthermore, displaced ravens merely moved onto adjacent towers. Disturbance tactics would probably be unsuccessful. The presence of roosting golden eagles and buteos did not displace roosting ravens from towers. Even the presence of nesting raptors only displaced roosting while young were in the nest. Therefore,

attempts to discourage raven roosting by using raptor decoys or encouraging raptors to nest on towers would appear to hold little promise. Feasible options for controlling contamination on the transmission line include shielding insulators of roost towers and discouraging ravens from roosting on critical sections of towers (i.e., those sections directly above insulators). Mechanical means of diverting ravens from certain tower sections appear to have the most potential for success.

Potential roost locations may be predictable. Roosts were concentrated between miles 101-156, which also supported a relatively high density of nesting ravens. The largest roost was located on the segment of line that had the highest density of nesting ravens, and was located near at least 2 historical, natural substrate roosts. The second largest roost (Marsing Southwest) was located near a natural substrate roost that was occupied during 1984. Roosts tended to be located in areas of relatively low topographic relief and near agricultural land. Roost locations and patterns of use may also have been related to availability and abundance of food sources.

ACKNOWLEDGMENTS

This study is a cooperative effort between the Pacific Power and Light Company (PP&L) and the Bureau of Land Management's (BLM) Snake River Birds of Prey Research Project. Clay Brown (PP&L) helped develop the study approach and provided the support of the transmission department. Keith Mitchell and Bob Martin (both PP&L) assisted with field work. Charles Allen, Bill Bruning, and Keith Walrath (all PP&L) provided logistical support. Roger Rosentreter (BLM) assisted with habitat evaluation, and Charles Baker (Boise State University) and Jeff Marks (BLM) assisted with identification of food remains. Nick Nydegger (University of Idaho) offered advice and assistance with statistical analyses. Aerial surveys were expertly piloted by John Meadows, Jerry Wilkerson, John Grow, and Bob Anthis. Discussions with Rick Knight (University of Wisconsin - Madison), Dave Paulin (U.S. Fish and Wildlife Service), Steve Platt (Black Butte Coal Company), Richard Stiehl (Southeast Missouri State University), and Steve Thompson (U.S. Fish and Wildlife Service) enhanced our understanding of ravens and are greatly appreciated.

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We thank Eb and Chris Evans, and Jesse and Pearl Peavy for their hospitality and support in providing a pleasant atmosphere in which to live while conducting field work.

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Appendix A. Times of first arrival at the Initial Point Roost, April-September 1984.

Date	Time of First Arrival (min in relation to sunset)
6 April	+ 1
10 April	-32
12 April	-15
15 April	-11
17 April	-45
19 April	- 5
22 April	-54
24 April	-20
26 April	-25
29 April	-36
1 May	-15
6 May	-20
8 May	- 2
10 May	-31
13 May	-11
15 May	-55
17 May	- 7
20 May	0
22 May	- 8
27 May	-11
29 May	-23
31 May	- 5
3 June	-31
7 June	- 8
12 June	-20
14 June	-30
17 June	-15
19 June	-40
21 June	-35
24 June	-20
28 June	- 5
1 July	-35
3 July	-25
10 July	-37
22 July	-60
2 August	-25
5 August	-40
12 August	-20
16 August	-25
19 August	-10
21 August	-10
26 August	-30
2 September	-10
9 September	-15

Appendix B. Times of last departure from the Initial Point Roost, April-September 1984.

Date	Time of Last Departure (min in relation to sunrise)
13 April	+ 4
20 April	+ 1
27 April	-24
11 May	+18
18 May	+17
08 June	+15
15 June	+25
22 June	+55
29 June	+16
06 July	+45
13 July	+20
27 July	+35
03 August	0
10 August	- 5
17 August	+ 5

TITLE: The Effects of Reconstruction Activities at the Swan Falls Hydroelectric Power Plant in Southwestern Idaho on a Breeding Population of Prairie Falcons

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John C. Smith, Wildlife Biologist, Idaho Power Company
Carmen Andonaegui, Volunteer
Sandy Spon, Volunteer

COOPERATOR: Idaho Power Company

OBJECTIVES:

1. To determine the effects of construction activities at Swan Falls on the behavior and productivity of a nesting population of prairie falcons.

2. To establish a data base from which management recommendations for the BPA can be developed.

3. To act as a pilot study which can function as a basis for future studies.

ANNUAL SUMMARY

The objective of this study was to evaluate the possible effects of road construction activities in the Snake River Birds of Prey Area (BPA) on the behavior and productivity of a nesting population of prairie falcons. The study was conducted from April through June 1984. A total of 8 prairie falcon breeding pairs was observed; 4 pairs in the treatment and 4 pairs in the control area. Prairie falcons reoccupied traditional nest sites 40-60 m above the new access road, although noise levels and traffic flows probably increased compared to previous years due to construction activities and improved accessibility of the Swan Falls area. Construction work also changed the cliff morphology. The road work was not completed until May 1984 when the falcons were rearing their chicks. Three disturbance variables (people, traffic and machinery) were used in analyses to determine their effects on prairie falcon behavior during incubation and brood-rearing. Noise levels were not used because they were constant over time. Strong associations between disturbance and behavioral variables could not be detected. Behaviors of prairie falcons in the treatment and control areas were not substantially different. Occupancy rate of nest sites in 1984 in the treatment area was similar to the period 1976 through 1978, but was lower for the control area. Productivity of chicks per nest site was higher in the treatment than in the control area. Productivity in both study areas was within the range of productivity reported in the BPA between 1973 and 1983. In general, the approach followed in this study

generated the information neccessary to evaluate the possible impacts of construction activities on nesting prairie falcons, thereby meeting the objectives of the 1984 pilot study.

INTRODUCTION

The Swan Falls hydroelectric power plant located in the Snake River Birds of Prey Natural Area (BPA) will be retrofitted over a period of 5 years (1983 through 1988). The reconstruction plans prompted Idaho Power Company to initiate a cooperative study with the Bureau of Land Management's Snake River Birds of Prey Research Project to evaluate the effects of construction activities on birds of prey. The prairie falcon (Falco mexicanus) was chosen for this study because it is the most numerous raptor in the BPA.

Construction in the Swan Falls Dam area started in October 1983 with reconstruction of an existing unpaved road leading down into the canyon. The new road was situated directly below 3 traditional prairie falcon nest sites. Heavy road construction (i.e., drilling and blasting) was completed between October 1983 and late January 1984 (Appendix I), in accordance with the permit granted to Idaho Power Company. Prairie falcons probably were not affected by these activities, since the falcons do not return to their nest sites until late January and do not lay eggs until late March (USDI 1979). However, the remaining road work was not completed until May 1984 when the prairie falcons were incubating or rearing their broods. The construction of the Swan Falls access road constituted the main disturbance in the Swan Falls area in 1983-1984.

Effects of Human Disturbance on Diurnal Raptors

Literature on the effects of human disturbance on diurnal raptors concentrates on nesting populations or sites where raptors concentrate to roost or feed. Human disturbance is defined as any human presence or activity which causes a change in the behavior of the species involved (Fraser 1984). Disturbance can be divided into 2 broad categories: (1) direct human activities, and (2) destruction or alteration of wildlife habitat. In general, disturbance parameters have not been found to correlate significantly with productivity (Fraser 1984). Prairie falcons, peregrine falcons (Falco peregrinus), ospreys (Pandion haliaetus) and bald eagles (Haliaeetus leucocephalus) have nested within 46-200 m of major highways without apparent effects on their productivity (Leedy 1972; Denton 1975; Olson and Olson 1980). Rock climbing can cause abandonment of nesting sites by prairie falcons and other raptors nesting along cliffs (Peterson and Stewart 1976; Boyce 1977; Boyce and Garrett 1977). Although diurnal raptors are mainly sight oriented (Brown 1976), sudden loud noises such as shooting and explosions may cause abandonment of eggs (Harmata, et al. 1978), or flush incubating adults from their nests, resulting in loss of eggs or small chicks (Platt 1975; Harmata, et al. 1978; Roseneau, et al. 1981). Mining activities may cause nest abandonment (Grier et al. 1977, 1978), or destroy cliffs used for nesting.

Effects of human activities on breeding raptors can occur during any phase of the breeding cycle. Clutches can be abandoned or deserted long enough to cause damage to the embryos, and chicks can be killed due to overheating or chilling if adults do not return in time to shelter them. Without parental protection, chicks may be killed by predators, or suffer from an inadequate food supply. Fledglings may leave the nest prematurely, decreasing their chance of survival (Parker 1972, 1973; Fyfe and Olendorff 1976). In general, raptors are most sensitive to disturbance during courtship and egg laying. Breeding raptors seem to be less vulnerable by the end of the incubation period, or when there are chicks (Newton 1979).

Two general conclusions can be made concerning the sensitivity of raptors to human disturbance: (1) considerable intra and interspecific variation exists in response of raptors to disturbance, and (2) much of the data on disturbance is anecdotal. In most studies, productivity of nesting raptor populations has been used as a criterion to evaluate the effects of disturbance (Fraser 1984). However, the behavioral response of raptors to human disturbance may be more gradual than an all-or-nothing situation. Changes in parental behaviors may occur before a threshold is passed and productivity starts to decline (Young 1980). Incubating, brooding, and defending the nest site may be critical behaviors. Few quantitative studies, however, have attempted to correlate changes in these types of behavior with human disturbance (Fraser 1984). Studies establishing such relationships, the approach taken in this study, are needed to develop raptor management practices that are based on factual data, not intuition (Suter and Joness 1981).

STUDY AREA

The study was conducted in the Snake River Birds of Prey Area (BPA) (Fig. 1), which is administered by the Bureau of Land Management. The BPA is a part of the Western Intermountain Sagebrush Steppe (West 1983). The climate in southwestern Idaho is characterized by mild winters and hot summers. A description of the vegetation and the natural environment can be found in USDI (1979) and West (1983). The BPA is unique in North America because of its high diversity and density of nesting raptors (Howard, et al. 1976; Olendorff and Kochert 1977; USDI 1979). The prairie falcon is the most numerous breeding raptor in the BPA, where it reaches its highest densities in North America (Ogden 1975; Howard, et al. 1976; USDI 1979). The treatment area (Swan Falls Dam study area) was centered around the construction site. The control area was located approximately 4 km downstream of Swan Falls Dam in an area similar in density of nesting raptors and cliff morphology to the treatment area (Fig. 2). A radius of 1 km was chosen for these areas, because this radius was judged to encompass at least the minimum area around the construction site where disturbance would be quantifiable (M. Kochert pers. comm.).

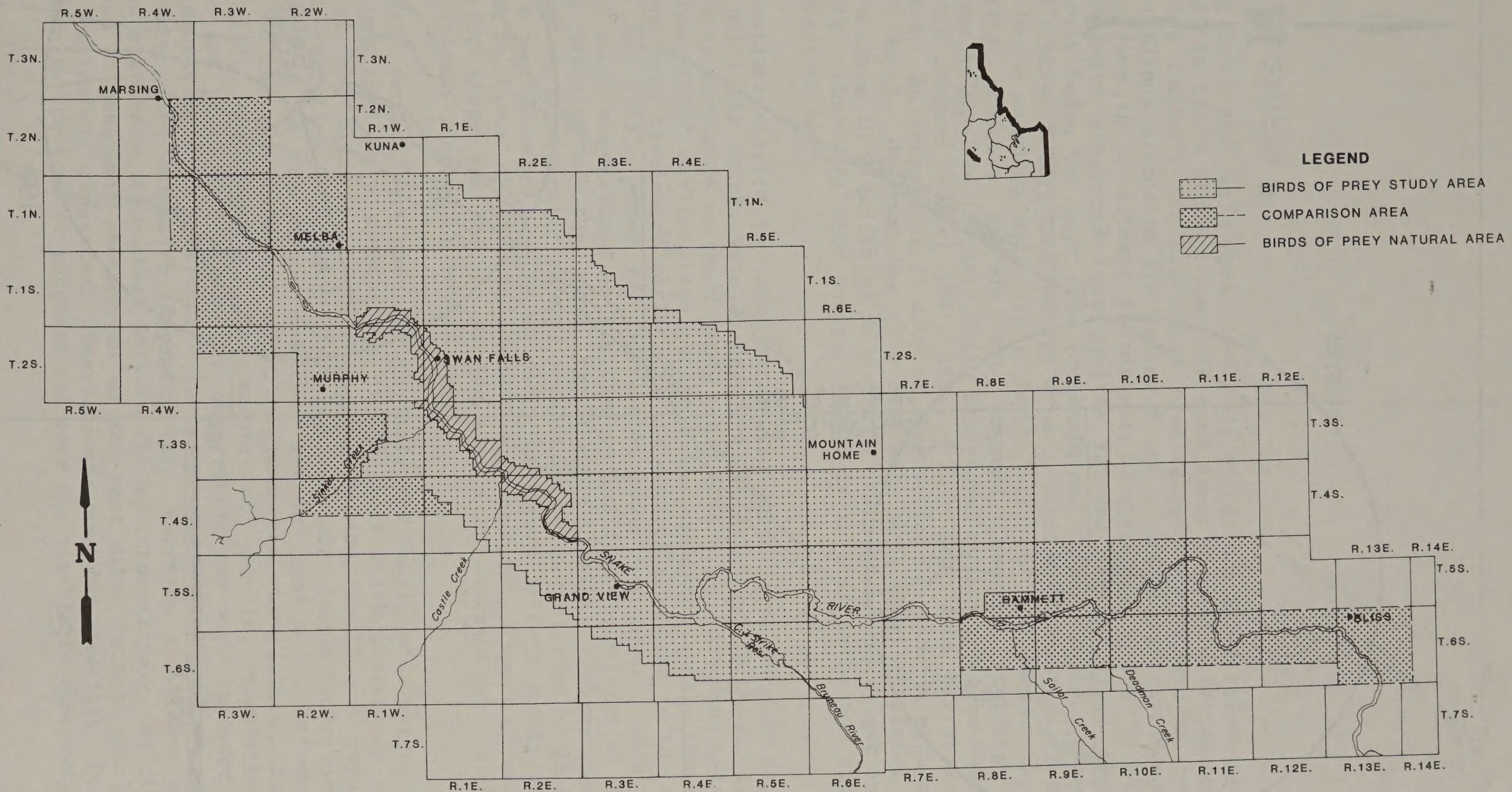

Fig. 1. Location of the Snake River Birds of Prey Natural Area

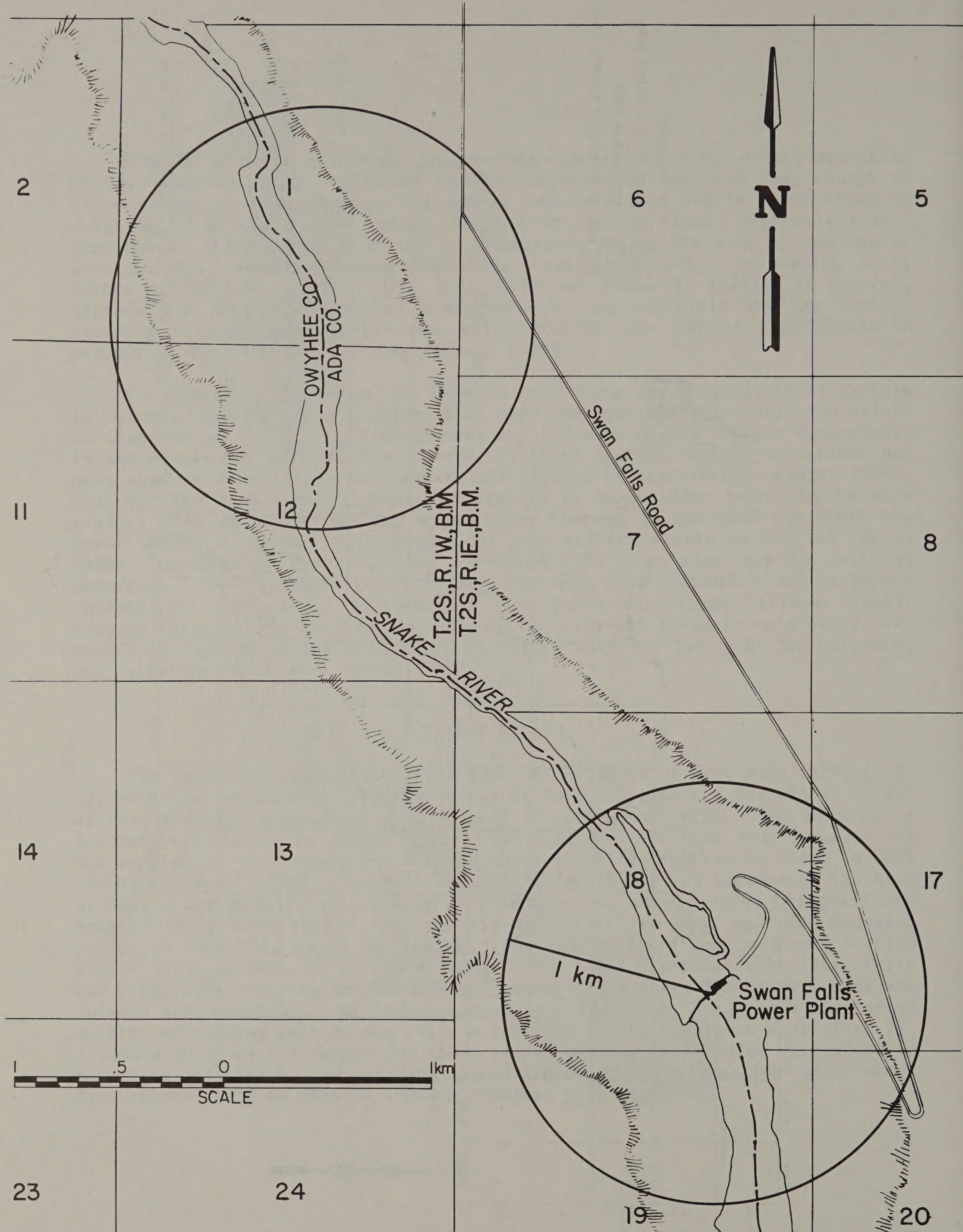

Fig. 2. Location of the treatment and the control area in the BPNA

METHODS

Behavioral Observations

During March and early April 1984, all occupied prairie falcon nest sites were located in the 2 study areas. In each area, 4 prairie falcon nest sites were selected randomly for behavioral observations. Observations took place from canvas blinds placed on the valley floor at an average distance of 200 m from the scrape in an attempt to minimize disturbance caused by observers. Previous research suggested that prairie falcons may not react strongly to human activity below the nest site (Peterson and Stewart 1976). Observations started 30 minutes before sunrise and were terminated 30 minutes after sunset. Thus, the basic sampling unit was a day. This unit was chosen because the entire daily activity pattern was covered, thereby avoiding sampling complications related to "normal" daily behavioral cycles and behavior affected by human disturbance (Fraser 1981, 1984). Each nest site was observed once every 6 days. An average of 11 days of observation was made at each nest site (range=9-13 days). Observations at a nest site were usually carried out by 2 observers working in 2 shifts of 8 hours to avoid observer fatigue and ensure data quality. Observers were assigned randomly to nest sites and study areas to avoid observer bias.

Observations started in early April when the falcons were incubating and continued until the chicks were 35 days old (late June). In total, 1292 hours of observation were made in the 2 study areas (Table 1). Breeding pairs in the control area nested earlier than pairs in the treatment area. Consequently, observations were terminated earlier in the control area than in the treatment area, and the total number of observation hours was fewer (Table 1). The incubation stage was defined as the time period from deposition of the first egg until hatching of the first egg (Heinroth 1922). Observations were discontinued at a particular site if incubation had not started by 15 April and a new site was selected. Only at one site (Lower Priest) observations were terminated in favor of another closely situated site (Upper Priest). The brood-rearing stage was defined as the time from hatching of the first egg until the falcons reached 35 days of age.

Separate records were made for the male and female of a pair. The sexes were distinguished by a combination of behaviors which positively identified the sex of the bird (e.g., food begging by the female and copulations), individual variation in plumage patterns, and the larger body size of the female compared to the male. For each sex and nest site, information was collected on the time (minutes) spent on pre-specified activities (Table 2 and Appendix II). Additionally, the number of patrols, copulations, prey deliveries and perch relocations per observation day were recorded for each sex. Interactions with territorial intruders were classified as aggressive, non-aggressive, and defensive (Appendix II). Perching locations, patrolling routes and aggressive encounters between the territorial pair and other birds were mapped on panoramic photographs of the nest site. Data on chick behavior were not collected; consistent observations were not feasible, because all scrapes were in crevices or recesses and were not visible to observers.

Table 1. Time (h) spent observing prairie falcons during the spring and summer of 1984 at Swan Falls, BPA.

Area	No. scrapes	No. days	No. hours
Treatment	4	49	713
Control	4	40	579
Total	8	89	1292
Total	8	89	1292

Table 2. Behavioral categories used in continuous observations on prairie falcons during the spring and summer of 1984 at Swan Falls, BPA.

Time period/day	Frequency/day	Plots
perching	patrol	perching distance to scrape
preening	aggressive encounter	
incubating	copulation	patrolling routes
brooding	prey delivery	
nest visit	relocation	
flight in canyon		
flight out of canyon		
feeding (adult/chick)		

Table 3. Weather information from January through June, Swan Falls Power House, 1984.

Month	1984 Max	1984 Min (°C)	1984 Mean	1950-1980 Max	1950-1980 Min (°C)	1950-1980 Mean	1984 Precip. (mm)	1950-1980 Precip. (mm)
January	0.6	-6.4	-2.9	4.9	-3.6	0.7	9.0	22.3
February	5.3	-3.1	1.1	9.5	-1.1	4.2	9.0	11.9
March	14.7	1.6	8.2	14.3	1.0	7.7	38.2	15.0
April	18.0	3.7	10.9	19.7	4.6	12.2	23.7	22.3
May	23.9	7.1	15.5	25.5	9.2	17.2	22.5	25.6
June	27.3	10.9	19.1	30.1	13.4	21.8	56.0	22.6

Chicks were aged using a photographic aging guide (Moritsch 1983). A breeding attempt was considered successful if one or more chicks reach 30 days of age (Steenhof and Kochert 1982). Productivity was determined as the number of chicks at each site that reached an age of 30 days. After fledging each scrape was inspected for dead chicks or signs of mortality. Physical characteristics, exposure, height of scrape below cliff base, accessibility to mammalian predators and shade class were recorded for each scrape according to the categories described in the Snake River Birds of Prey Research Project Instruction Handbook (U.S. Bur. Land Manage., Boise District, Boise, Idaho).

Disturbance Quantification

Four parameters of human disturbance were quantified: (1) noise (in dB), (2) traffic flow (number of vehicles passing specific points), (3) number of pieces of heavy machinery passing through the 2 study areas, and (4) people (number of people and the activity they were engaged in). Noise levels were measured using an industrial noise dosimeter (Type 1954 Personal Noise Dosimeter, GenRad, Concord, Mass.). Noise levels (equivalent sound levels in dB) in the treatment area were determined at increments of 200 m from the dam site up to a maximum distance of 1000 m and at 4 measurement points on the Swan Falls access road, once every 6 days (Fig. 3). At each sample location 3 replicate measurements were made, each over a 30 second interval. Noise levels in the control area were determined in the same manner (Fig. 3). Simultaneously, continuous noise measurements were conducted at Swan Falls Dam by placing a noise dosimeter in the weather station for approximately 8 hours.

Traffic flows were measured with traffic counters (Autocount Cumulative Counter, Highway and Traffic Data Systems, Golden River Corp., Rockville, Md.) placed at (1) the Swan Falls access road, (2) 250 m upstream on the road parallelling the Snake River on the east side, and (3) likewise 250 m downstream on the road parallelling the Snake River (Fig. 3). The number of people involved in recreational activities (both legal and illegal) in both areas were counted and their recreational activities classified into four categories, (1) watching scenery, (2) watching birds, (3) throwing rocks down the cliff, and (4) discharging firearms.

Weather Information

Weather information (minimum and maximum daily temperature (C.), total daily precipitation (mm) was collected by Idaho Power employees at the official National Weather Station located near the Swan Falls Power House.

Data Analysis

Hatching dates were based on the estimated ages of chicks. Approximate laying dates for eggs were based on a 34-day incubation period for prairie falcon eggs (Burnham 1983). Observations at a particular nest site were classified according to the estimated developmental stage of either eggs or chicks (i.e., incubation or brood rearing stage). Comparisons of behaviors of

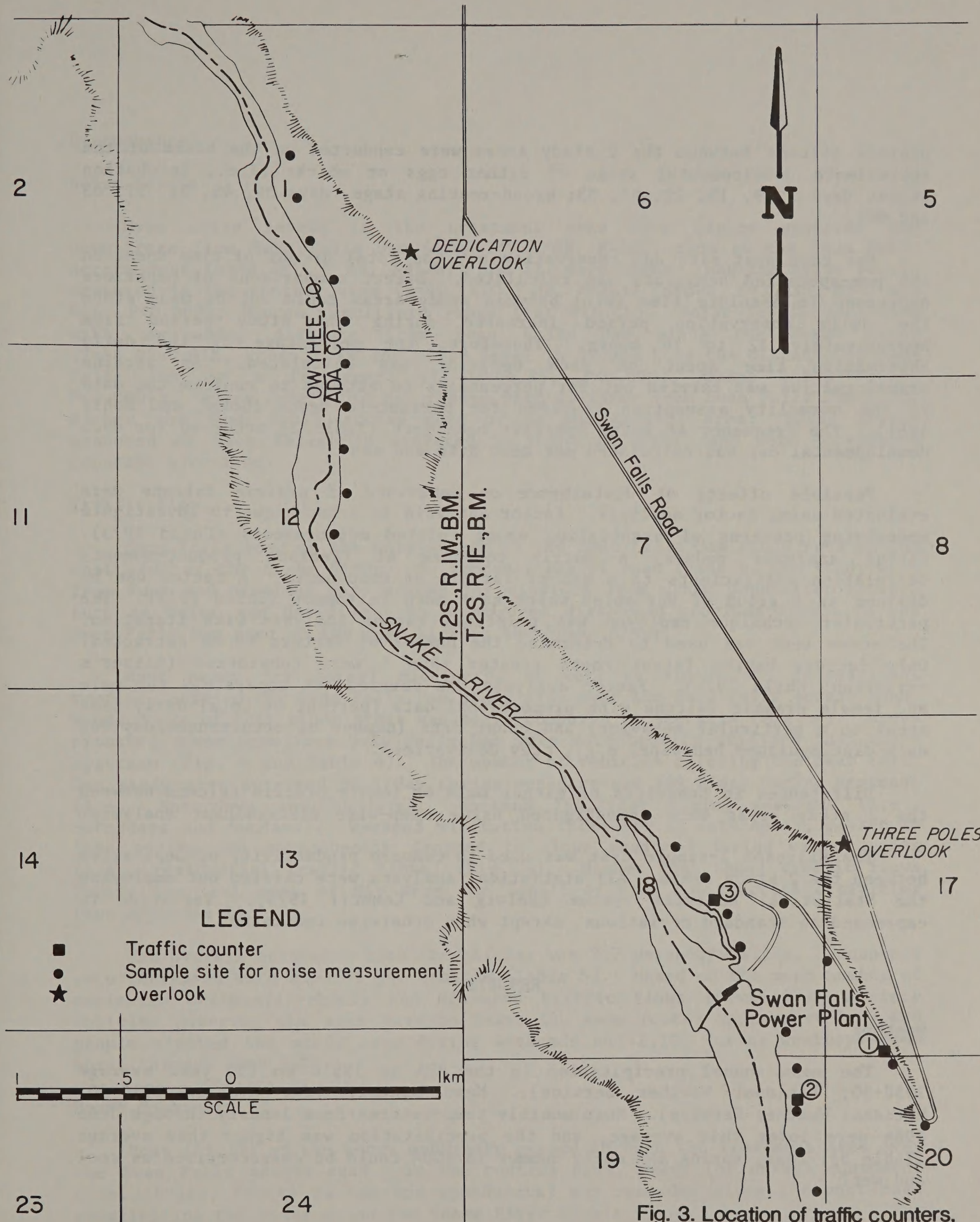

Fig. 3. Location of traffic counters, sample sites for noise measurements, and the overlooks in the treatment and control areas, BNPA

prairie falcons between the 2 study areas were conducted on the basis of the approximate developmental stage of either eggs or chicks (i.e., incubation stage, days 3, 9, 15, 21, 27, 33; brood-rearing stage, days 39, 45, 51, 57, 63 and 69).

For each nest site and observation day the total amount of time spent on the pre-specified behaviors was calculated. Direct comparisons of behaviors expressed in absolute time (min) between study areas could not be made since the daily observation period increased during the study period from approximately 12 to 16 hours. Therefore, the percentage of the daily observation time spent on each behavior was calculated. An arcsine transformation was carried out for percentages to attempt to conform the data to the normality assumption required for parametric tests (Sokal and Rohlf 1981). The frequency at which specific behaviors (Table 2) occurred for each developmental day was calculated per nest site and sex.

Possible effects of disturbance on behaviors of prairie falcons were evaluated using factor analysis. Factor analysis is a technique to investigate underlying patterns of association among related measurements (Child 1973). Factor analysis reduces a matrix composed of (Pearson product-moment) correlation coefficients to a set of factors or components. A factor can be defined as a group of variables which have much in common (Child 1973). The particular technique employed was principal factor analysis with iteration. The scree test was used to determine the number of factors to be extracted. Only factors having latent roots greater than 1 were considered (Kaiser's criterion; Child 1973). Factor analysis was carried out separately for male and female prairie falcons with proportional data (percent of total daily time spent on a particular behavior) and count data (number of occurrences/day for each distinguished behavior, e.g., prey deliveries).

Differences in behaviors of either male or female prairie falcons between the 2 study areas were investigated using step-wise discriminant analysis.

The Wilcoxon 2-sample test was used to compare productivity of nest sites between the 2 study areas. All statistical analyses were carried out employing the Statistical Analysis System (Helwig and Council 1979). Variation is expressed as standard deviations, except when otherwise indicated.

RESULTS

Weather

The mean annual precipitation in the BPA is 195.6 mm (30 year average 1950-80; National Weather Service). Mean monthly year average 1950-80; National Weather Service). Mean monthly temperatures from January through June 1984 were lower than average, and the precipitation was higher than average (Table 3). Thus, spring and early summer in 1984 could be characterized as cool and wet.

Disturbance

Noise Levels

Mean noise levels in the treatment area were higher upstream and downstream from Swan Falls Dam ($\bar{x}$=46.7+9.5 dB, N=302) than at the Swan Falls access road ($\bar{x}$=43.7±11.2 dB, N=126), and all were higher than the noise levels measured in the control area ($\bar{x}$=40.1±10.1 dB, N=261) (ANOVA, F=30.35, df=2 and 686, P<0.0001; Duncan's multiple range test P<0.05). Noise levels decreased with increasing distance from Swan Falls Dam along the Snake River (Y=54.02-0.01X, where Y is the noise level in dB and X is the distance to Swan Falls Dam in m (intercept t(I=0)=46.25, P<0.0001, slope t(b=0)=-6.94, P<0.0001). Noise levels did not change with distance from Swan Falls Dam along either the Swan Falls access road or in the control area. Noise levels measured at Swan Falls Dam averaged 58.3±3.6 dB (N=11) and were considered constant over time.

Traffic Flow

Swan Falls road is the only access to the Swan Falls Dam study area on the east side of the Snake River. An improved gravel road leads to the study area from Kuna and provides easy access for visitors from urban population centers such as Boise and Meridian. An unimproved dirt road provides access to the Swan Falls Dam area on the west side of the Snake River.

Most heavy (or noisy) machinery, as well as almost all recreational traffic, entered the Swan Falls Dam study area over the Swan Falls access road. Weekend use of both study areas was heavy compared to weekdays (Fig. 4). Areas situated downstream from Swan Falls Dam were more heavily utilized than those upstream (Fig. 4 and Table 4). The number of vehicles entering the Swan Falls Dam study area averaged 68.1/day during weekdays and 169.2/day during weekends (i.e., Saturdays and Sundays). Weekend 169.2/day during weekends (i.e., Saturdays and Sundays). Weekend visitation increased in late April, peaked in late spring and subsequently dropped to flows measured during early spring (i.e., residential traffic flows) (Fig. 4). Higher than usual traffic flows during the last week of May were the result of road construction activities (see Appendix I).

The overall occupancy rate of vehicles was 3.7 persons/vehicle. Occupancy rate increased with size of the vehicle (Table 5). Based on the mean number of estimated occupants/vehicle and measured traffic flows (divided by 2 since vehicles entering the area have to leave the same route) approximately 7,800 people visited the study area during weekends and 2,100 during weekdays from April through June 1984.

Heavy Machinery

Most (81.7%) of the heavy machinery passed through the treatment area over the Swan Falls access road. In the control area, heavy (or noisy) equipment (i.e., buses, trucks >2 ton and speedboats) was recorded along the east road parallelling the river or on the Snake River (Table 6).

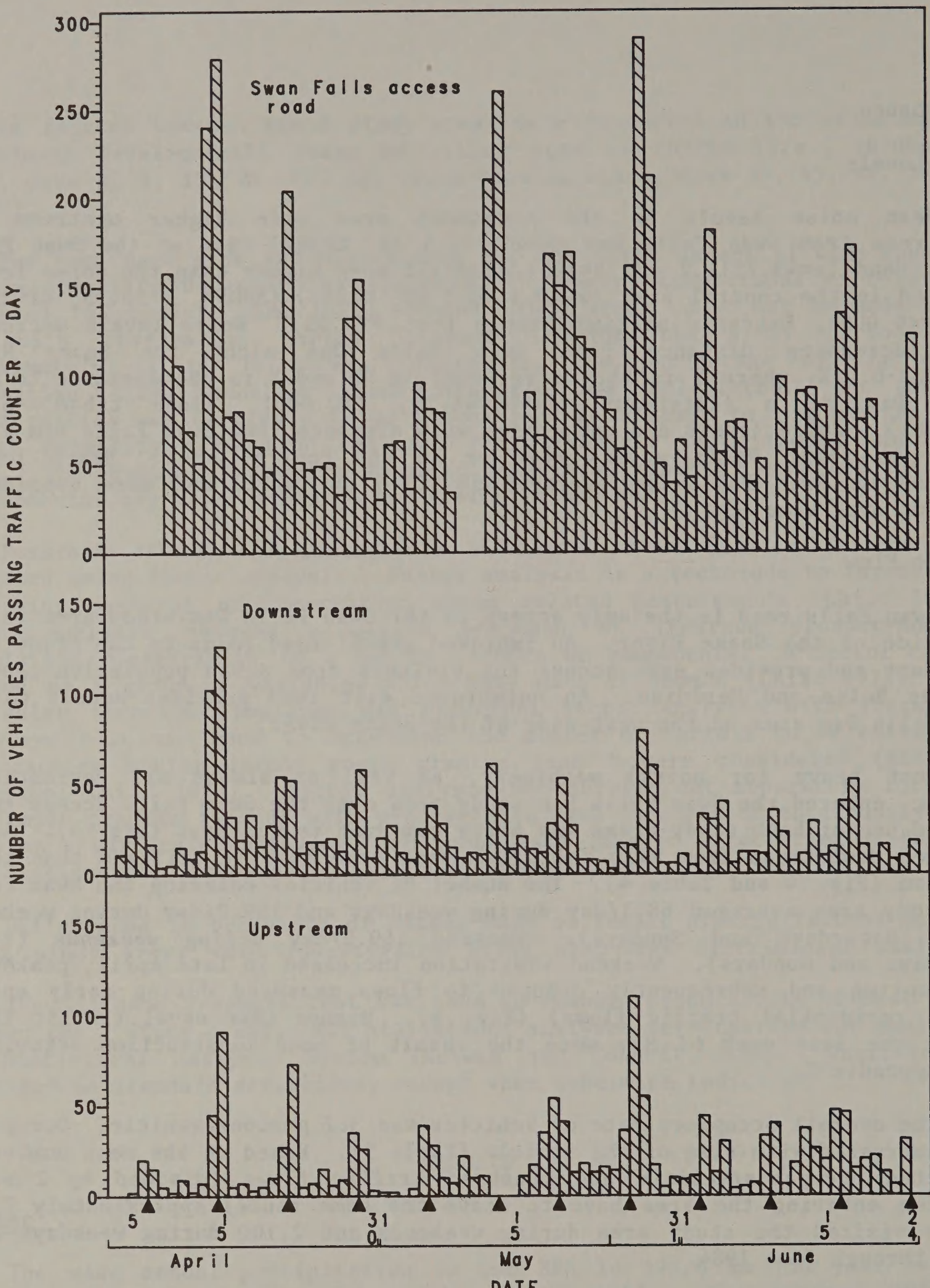

Fig. 4. Daily traffic flows at the Swan Falls access road, upstream and downstreams from Swan Falls Dam.

Table 4. Mean number of vehicles per day (±SD) passing the 3 traffic counter locations during weekend-days and weekdays, BPA, April through June 1984.

Location	Weekend-day			Weekday		
	Mean	SD	N	Mean	SD	N
Swan Falls Road	169.2	62.1	21	68.1	28.2	50
Upstream	42.5	24.3	22	11.4	8.3	53
Downstream	47.5	26.2	24	14.4	8.0	56

Table 5. Number of people by vehicle class counted in both study areas, BPA, April through June, 1984.

Vehicle class	Occupants/vehicle		
	Mean	SD	N
Bus	25	0	2
Car	3.3	1.4	40
Small truck	3.0	1.0	60
Van	4.5	2.3	22
Total	3.7	2.9	144

Table 6. Number of heavy or excessively noisy machinery recorded in the control and treatment areas, BPA, April through June, 1984.

Machine	Area		
	Treatment	Control	Sum
Truck	53	2	55
Bus	4	0	4
Speedboat	0	3	3
Miscellaneous	10	10	20

Recreation

More people were involved in recreational activities in the control area (340 persons) than in the treatment area (103 persons) from April through June 1984 (Table 7). Overlooks located along the access road to the BPA attracted most visitors in the control area (Dedication Overlook; 277 persons (81.4%)) as well as in the treatment area (Three Poles Overlook; 88 persons (85.4%)). Other visitors in both areas were noted at various locations along the canyon wall (9 and 35 persons in the treatment and control area, respectively). Peak visits occurred in both study areas in the late morning and early afternoon (Fig. 5). The majority of visitors watched the scenery or birds (82.5 and 76.7% of all visitors in the treatment and control areas, respectively). Other activities were less peaceful and consisted of repeatedly throwing rocks or boulders down the cliffs or discharging firearms (Table 7). These activities were centered around the overlooks (Fig. 3). Discharging of firearms was more prominent in the control area than in the treatment area. Visitors practiced target shooting, or did not seem to aim at anything in particular, but appeared to gain satisfaction from the noise they produced. In 3 instances people were observed shooting at animals, thereby killing a yellow-bellied marmot (Marmota flaviventris) and a western rattlesnake (Crotalus viridis). Visitors also were recorded to shoot at fish in the river. Although in one case people appeared to be shooting at the canyon wall, possibly at birds, no casualties were observed or found. One dead and presumably shot great horned owl (Bubo virginianus) found by Idaho Power employees on the west side of the Snake River constituted the only suspected killing of a raptor.

Disturbance in the Treatment versus Control Area

Comparisons were made between variables of disturbance in the treatment and control areas on a daily basis (Table 8). More people visited the control area than the treatment area (6.8 and 2.1 persons/day, respectively). Traffic flows were higher in the treatment area than in the control area (102.7 and 25.4 treatment area than in the control area (102.7 and 25.4 vehicles/day, respectively) as were the numbers of heavy machinery (1.4 and 0.3 heavy machinery/day, respectively).

Associations Between Variables of Disturbance and Behavior

Three parameters of disturbance were evaluated for their possible effects on behaviors of adult male and female prairie falcons: (1) daily number of visitors, (2) daily traffic flow, and (3) daily number of heavy machinery passing through both the control and treatment areas. Traffic flows were not actually measured in the control area, but the data collected at traffic counter no. 3 (Fig. 3) were used as an index of traffic flow in the control area. Noise levels were not used, because these values remained constant in both study areas, precluding their usefulness as a disturbance variable. The information collected on noise levels will serve as background data for comparisons in coming years.

Table 7. Numbers of visitors, their activities and location in the treatment and control areas, BPA, April through June, 1984.

	Area Location	Activity 1	2	3	4	S
T						
R	Three Poles	50	20	16	2	88
E	Swan Falls access road	2	0	3	0	5
A	Dam downstream	1	0	0	0	1
T	Swan Road Turn	0	0	0	2	2
M	Falcon Flats Fingers	0	0	4	1	5
E	Bend	0	0	0	2	2
N						
T	Total	53	20	23	7	103
	Dedication Overlook	189	43	30	15	277
C	Snake River Road East	0	0	0	11	11
O	Fisherman's Point	0	0	0	11	11
N	PF I	0	2	0	0	2
T	PF II	5	0	0	0	5
R	Priest Rapids I	0	0	0	2	2
O	Priest Rapids II	0	0	0	2	2
L	Priest Ranch	0	0	0	6	6
	Stage Coach Road	22	0	2	0	24
	Total	216	45	32	47	340

1=watching scenery
2=watching birds
3=throwing rocks
4=discharging firearms
S=sum

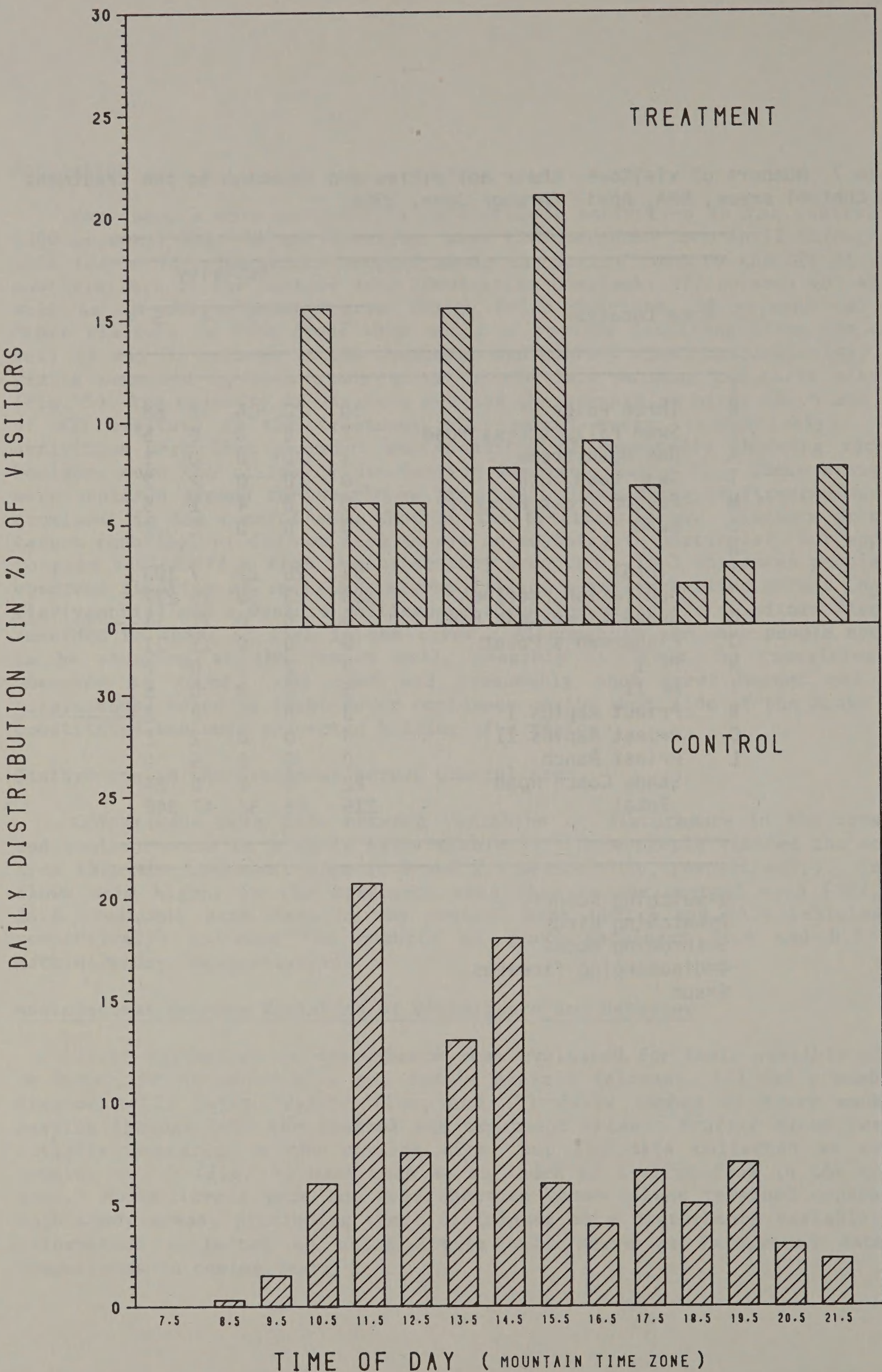

Fig. 5. Daily time distribution of people visiting the control and treatment areas, BPNA.

Table 8. Differences in disturbance levels between treatment and control areas, BPA, April through June 1984.

Variable	Treatment Mean	Treatment SD	Treatment N	Control Mean	Control SD	Control N	t	df	P
People	2.1	4.9	49	6.8	13.4	49	-2.32	61	0.023
Machinery	1.4	3.9	49	0.3	0.7	49	1.86	51	0.067
Traffic	102.7	68.4	43	25.4	23.3	49	7.05	51	0.0001*

1) Number of people/day
2) Heavy machinery/day
3) Vehicles/day

The possible effects of disturbance activities on behaviors were evaluated by employing factor analysis. Analyses were carried out with behavioral data on male and female falcons expressed as percentages of the total observation time per day (e.g., percent of day perching and preening), or number of occurrences per day (e.g., patrols, copulations) and disturbance parameters. In both analyses, 6 common factors were extracted for both male and female prairie falcons (Tables 9 and 10). Only factor loadings greater than |0.30| were considered because this loading level ensures a rigorous criterion for significance (Child 1973). Four general observations can be made concerning the common factors (Tables 9 and 10). First, the loadings were small. Second, the variance explained by the common factors for each variable (communality h^2) was small. Third, the proportion of the variation explained by each factor was consistently low, suggesting weak association among variables. Fourth, consistent patterns between disturbance and behavioral variables were not observed, i.e., groupings of variables were not not repeated in each of the common factors. Thus, associations between behavioral and disturbance variables could not be detected for either ioral and disturbance variables could not be detected for either male or female prairie falcons.

Behavior of Prairie Falcons in the Control and Treatment Areas

Behaviors of male and female prairie falcons during incubation and brood rearing were investigated for differences between the treatment and the control area. Analyses were carried out separately with percentage and count data (Tables 11 and 12, respectively). The averaged squared canonical correlation coefficients (ASCC) calculated with percentage data were low for both sexes (ASCC<0.20) (Table 11). An ASCC close to 1 would suggest strong differences in behaviors between the 2 study areas. Thus, the low ASCC's suggest no substantial differences in overall behaviors between the 2 study areas. However, some behaviors showed differences between the 2 study areas. Males spent more time perching during incubation and less time hunting during brood rearing in the control than in the treatment area (ANOVA, brood rearing in the control than in the treatment area (ANOVA, F=6.77, df=1 and 39, P=0.01 and F=9.19, df=1 and 44, P<0.01, respectively). During brood rearing males in the control area were out of sight longer than in the treatment area (ANOVA, F=10.50, df=1 and 44, P<0.01). Females spent less time hunting in the control than in the treatment area (ANOVA, F=11.68, df=1 and 44, P<0.01). However, coefficients of determination (R^2) were small (<0.20) (Table 11). Similarly, stepwise discriminant analysis was carried out with count data for both sexes (Table 12). Again, ASCC's were low for both sexes (ASCC<0.20) which suggests little difference in behaviors between the two study areas. The number of aggressive interactions and patrols was higher for males during incubation and brood rearing in the control than in the treatment area (aggression: ANOVA, F=8.44, df=1 and 39, P<0.01 and F=5.27, df=1 and 44, P=0.02; patrolling: F=4.71, df=1 and 39, P=0.03, F=3.24, df=1 and 44, P=0.07, respectively). However, coefficients of determination were again small (R^2 <0.20) (Table 12).

Table 9. Factor matrix for disturbance parameters and behaviors of male and female prairie falcons (behaviors expressed as percentages of total observation time/day), field season 1984.

	Male							Female						
	Common Factor Loadings						Communality (h^2)	Common Factor Loadings						Communality (h^2)
Variables	I	II	III	IV	V	VI		I	II	III	IV	V	VI	
People	0.01	-0.05	0.69	-0.08	0.34	0.06	0.61	-0.03	-0.45	-0.60	-0.14	0.44	0.13	0.80
Machinery	-0.23	0.17	-0.03	0.52	0.08	-0.29	0.45	-0.09	0.19	-0.08	0.70	0.40	-0.03	0.71
Traffic	-0.21	-0.19	-0.20	0.19	0.32	-0.01	0.26	-0.09	0.27	-0.14	-0.03	0.29	0.13	0.21
Perching	0.61	-0.06	0.11	0.20	0.13	-0.005	0.44	0.61	0.14	-0.05	-0.12	0.09	0.32	0.53
Preening	0.20	0.14	-0.30	0.05	0.19	0.23	0.25	0.30	-0.12	-0.23	-0.04	0.04	0.21	0.21
Incubation/ brooding	-0.59	0.42	0.12	0.01	-0.10	0.21	0.60	-0.79	0.21	0.07	-0.11	-0.06	0.01	0.69
Nest visit	0.03	0.12	-0.21	0.02	0.12	0.22	0.12	0.54	0.67	0.34	-0.16	0.10	-0.28	0.99
Canyon flight	0.23	-0.25	0.19	0.40	-0.37	0.23	0.52	-0.10	0.14	-0.01	-0.04	0.09	0.18	0.07
Relocation	0.54	0.12	-0.14	-0.08	0.06	0.02	0.34	0.51	-0.28	0.24	0.10	-0.03	-0.08	0.42
Hunting	0.31	0.25	0.03	-0.20	-0.18	-0.22	0.29	0.23	-0.10	0.49	0.42	0.39	0.08	0.64
Out of sight	-0.26	-0.65	-0.13	-0.17	-0.02	-0.01	0.54	0.09	-0.42	-0.09	-0.09	0.21	-0.38	0.39
Lateral root	1.39	0.86	0.77	0.60	0.49	0.35	4.47	1.76	1.14	0.88	0.77	0.68	0.46	5.71
Proportion variation (%)	0.17	0.12	0.12	0.10	0.09	0.08		0.19	0.13	0.11	0.09	0.09	0.08	

Table 10. Factor matrix for disturbance parameters and behaviors of male and female prairie falcons based on count data, (number of occurrences/day), field season 1984.

	Male							Females						
	Common Factor Loadings						Communality (h^2)	Common Factor Loadings						Communality (h^2)
Variables	I	II	III	IV	V	VI		I	II	III	IV	V	VI	
People	0.22	0.13	-0.24	0.30	0.19	-0.27	0.33	0.11	0.44	0.80	0.19	0.16	0.11	0.93
Machinery	-0.39	0.32	-0.03	-0.12	0.12	0.09	0.29	0.21	-0.34	0.00	0.32	0.05	-0.10	0.28
Traffic	-0.35	0.06	-0.06	0.37	<0.001	0.33	0.38	0.21	-0.22	0.13	-0.12	-0.23	-0.05	0.18
Nest visits	-0.29	0.05	0.70	0.30	0.01	-0.10	0.69	0.31	-0.14	-0.08	-0.07	0.11	0.40	0.31
Patrolling	0.29	0.04	-0.02	0.36	0.26	-0.02	0.29	0.48	0.23	-0.05	0.19	-0.55	0.13	0.66
Aggression	0.54	0.06	0.28	-0.26	0.36	0.11	0.59	0.29	0.52	-0.27	0.00	-0.06	0.13	0.46
Copulation	-0.57	0.48	0.00	-0.23	0.18	-0.17	0.69	0.46	-0.45	<0.001	0.42	0.16	-0.02	0.63
Canyon flight	0.37	0.68	-0.23	0.08	-0.29	0.04	0.75	0.61	0.06	0.12	-0.38	0.13	-0.29	0.65
Relocation	0.33	0.25	0.45	-0.15	-0.20	0.03	0.45	0.26	0.31	-0.34	0.06	0.40	0.01	0.46
Feeding adult	0.07	0.25	0.02	0.10	0.32	0.14	0.20	0.21	-0.19	0.02	-0.43	0.06	0.31	0.37
Feeding chick	0.07	0.12	0.20	0.24	-0.18	-0.05	0.15	-0.07	0.29	-0.24	0.22	0.08	0.19	0.24
Lateral root	1.40	0.98	0.94	0.69	0.56	0.27	4.87	1.24	1.17	0.94	0.77	0.62	0.45	5.21
Proportion variation (%)	0.28	0.20	0.19	0.14	0.11	0.05		0.23	0.22	0.18	0.14	0.12	0.08	

Table 11. Stepwise discriminant analysis to evaluate differences in behaviors (expressed as percentages of total observation time/day) between prairie falcons in the control and treatment areas for incubation and brood rearing stages, field season 1984.

	Incubation						Brood rearing					
	Male			Female			Male			Female		
Behavior	R^2	F	P	R^2	F	P	R^2	F	P	R^2	F	P
Perching	0.14	6.77	0.01	<0.01	<0.01	0.97	<0.01	0.26	0.60	0.02	1.33	0.25
Preening	<0.01	0.18	0.66	0.02	0.99	0.32	0.01	0.56	0.45	0.03	1.81	0.18
Incubation	0.03	1.25	0.27	<0.01	<0.01	0.99	-	-	-	-	-	-
Brooding	-	-	-	-	-	-	<0.01	0.13	0.71	<0.01	0.02	0.88
Nest visit	0.02	0.98	0.32	0.03	1.41	0.24	0.02	0.92	0.34	0.01	0.88	0.35
Relocation	0.07	3.22	0.08	0.03	1.45	0.23	0.02	0.94	0.33	0.01	0.52	0.47
Hunting	0.01	0.72	0.39	0.04	1.87	0.17	0.17	9.19	<0.01	0.20	11.68	<0.01
Out of sight	0.04	1.81	0.18	<0.01	0.04	0.83	0.19	10.50	<0.01	0.01	0.49	0.48

ASCC male (incubation)=0.147
ASCC male (brood rearing)=0.192
ASCC female (incubation)=0.098
ASCC female (brood rearing)=0.209

Table 12. Stepwise discriminant analysis to evaluate differences in behaviors (expressed as counts/day) between prairie falcons in the control and treatment areas for incubation and brood rearing stages, field season 1984.

	Incubation						Brooding					
	Male			Female			Male			Female		
Behavior	R^2	F	P	R^2	F	P	R^2	F	P	R^2	F	P
Nest visits	0.18	8.83	<0.01	<0.01	0.05	0.81	0.03	1.60	0.21	0.01	0.51	0.47
Patrolling	0.10	4.71	0.03	<0.01	0.02	0.87	0.06	3.24	0.07	<0.01	0.16	0.68
Agression	0.17	8.44	<0.01	0.05	2.40	0.12	0.10	5.27	0.02	0.07	3.64	0.06
Copulation	0.04	1.98	0.16	0.02	1.00	0.32	<0.01	0.12	0.73	<0.01	0.21	0.64
Flight in canyon	<0.01	0.06	0.80	0.07	3.25	0.07	0.03	1.42	0.23	<0.01	<0.01	0.93
Relocation	0.04	1.67	0.20	0.01	0.57	0.45	0.04	2.13	0.15	0.13	6.83	0.01
Feeding adult	<0.01	0.17	0.68	0.01	0.66	0.41	0.03	1.77	0.18	0.03	1.53	0.22
Feeding chick	-	-	-	<0.01	<0.01	0.93	<0.01	0.08	0.76	0.13	6.64	0.01
Prey deliveries	0.05	2.11	0.15	-	-	-	<0.01	0.02	0.87	0.01	0.49	0.48
Prey cached	0.01	0.43	0.51	<0.01	0.21	0.88	<0.01	0.11	0.73	0.05	2.44	0.12
Prey retrieved	0.02	0.93	0.33	<0.01	0.11	0.73	<0.01	<0.01	0.95	<0.01	0.31	0.57

ASCC male (incubation)=0.184
ASCC male (brood rearing)=0.107
ASCC female (incubation)=0.137
ASCC female (brood rearing)=0.134

Productivity and Nest Site Occupancy

Productivity (i.e., the number of chicks 30 days or older per nest site) was higher in the treatment area ($\bar{x}$=3.6 chicks/nest site) than in the control area ($\bar{x}$=2.2 chicks/nest site) (Table 13). However, sample sizes were too small to draw a strong conclusion (Wilcoxon 2-sample test, z=1.73, P=0.08) concerning the difference in productivity between the 2 areas.

Occupancy rate of nest sites in the treatment and control area in 1984 was compared to records over the period 1976-78 (Appendix III), because only in those years was a complete survey made of both areas. The occupancy rate of nest sites in the treatment area (83%; 5 of 6 nest sites) was within the range of recorded rates from 1976 through 1978 ($\bar{x}$=83%, range=67-100%), but was lower in the control area (58%; 7 of 12 nest sites) compared to the same period ($\bar{x}$=88%, range=83-100%) (Table 14).

In the treatment area the Balls Basin Powerline nest site, a traditional nest site located directly below the new road, was not occupied in 1984. This nest site could have been affected by construction activities which took place on the canyon rim directly above the nest site intermittently from January through May 1984. However, the nest site also had been vacant in 1982 and 1983 (Appendix III).

Behavior of Prairie Falcons During Incubation and Brood Rearing

In previous analyses differences in falcon behaviors could not be detected between the 2 study areas. Therefore, the behavioral data from both areas were combined for each sex.

Daily Time Budget

Both sexes spent similar amounts of time perching and preening during incubation (Fig. 6 and Table 15). The time spent perching and preening by both sexes increased during brood rearing. Time allocated to perch relocation showed similar trends during incubation and brood rearing for both males and females (Table 15). Males spent a larger proportion of their daily time budget during incubation outside the canyon, probably hunting, than females (male=33% versus female=7%). Both sexes increased their hunting activities during the brood rearing phase (male=47% and female=18%). Successful hunting by the female was strongly suggested by a full crop upon return to the nest site and occasionally by caching of prey. Females spent an average 68% (range=15-98%) of the daylight hours incubating and males 21% (range=1-46%). Females probably incubated during the night, because in general they were last observed in the scrape within 30 minutes after sunset (33 out of 41 days) (Table 16). More time was spent brooding by females ($\bar{x}$=20%, range=1-85%) than males ($\bar{x}$=3%, range=1-34%) (Table 15). Apparently, only females brooded the chicks during the night (Table 16). Chicks were brooded in some cases until well in their third week (Table 16). The behaviors discussed above account for more than 90% of all activities during the day. Other activities such as aggressive interactions and prey deliveries accounted for only a fraction of the total daily time budget, but their frequency of occurrence on a daily basis is

Table 13. Productivity (chicks >30 days) of prairie falcons in the treatment and control areas, BPA, 1984.

Treatment	Control
3.6±0.9 (N=5)	2.2±1.8 (N=6)
z=1.73, P=0.083	

Table 14. Occupancy rate (%) of inspected prairie falcon nest sites in the treatment and control areas in the BPA.

	Occupancy rate (%)			
	Treatment		Control	
Period	Mean	Range	Mean	Range
1976-1978	83	67-100	88	83-100
1984	83		58	

Fig. 6. Daily time budget for male and female prairie falcons during the 1984 breeding season.

Table 15 A&B. Behavioral time allocation (behaviors expressed as proportions of total daily observation time) for male (A) and female (B) prairie falcons (8 pairs) during incubation and brood rearing.

A

	Male							
	Incubation				Brood rearing			
Behavior	Mean	SD	Range	N	Mean	SD	Range	N
Perching	5.7	5.9	0.1-23.0	41	10.6	7.4	1.6-31.6	46
Preening	3.3	3.1	0.6-11.0	41	5.2	3.4	0.1-13.2	46
Incubation	21.4	11.9	0.8-46.1	41	-	-	-	-
Incubation	21.4	11.9	0.8-46.1	41	-	-	-	-
Brooding	-	-	-	-	3.1	7.2	0.1-33.9	46
Nest visit	0.4	1.4	0 - 8.6	41	0.4	0.5	0 - 2.4	46
Relocation	6.1	7.3	0.1-27.9	41	9.6	8.4	1.1-35.3	46
Hunting	32.9	18.6	2.8-71.2	41	47.2	21.0	6.7-93.2	46
Out of sight	21.1	19.6	0.3-75.4	41	12.8	12.5	0.1-53.4	46

B

	Female							
	Incubation				Brood rearing			
Behavior	Mean	SD	Range	N	Mean	SD	Range	N
Perching	2.9	3.3	0.1-10.7	41	16.2	14.4	0.6-75.7	46
Preening	3.8	3.7	0.2-17.9	41	6.1	4.7	0.1-21.0	46
Incubation	67.7	15.6	15.1-98.3	41	-	-	-	-
Brooding	-	-	-	-	19.8	27.6	0.7-85.0	46
Nest visit	0.1	0.2	0.1- 0.9	41	0.3	0.5	0.1- 2.2	46
Nest visit	0.1	0.2	0.1- 0.9	41	0.3	0.5	0.1- 2.2	46
Relocation	4.1	4.7	0.1-22.2	41	15.7	12.5	0.3-51.0	46
Hunting	7.2	11.3	0.4-46.0	41	18.3	18.2	0.2-58.5	46
Out of sight	9.3	15.2	0.2-82.2	41	8.8	11.2	0.1-46.6	46

Table 16. Presence of male or female prairie falcon at a nest site 30 minutes after sunset during incubation and brood rearing.

Location	Incubation			Brooding			Age of chick at last night of brooding
	M	F	N	M	F	N	
Three Poles	1	5	6	0	2	2	12
Swan Road N Side	1	5	6	0	2	2	18
Ferry	2	4	6	0	4	4	24
Falcon Flats Fingers	0	6	6	0	3	3	18
Falcon Flats Fingers	0	6	6	0	3	3	18
Priest Rapids I	2	4	6	0	3	3	18
PF I	1	2	3	0	3	3	18
PF II	1	4	5	0	3	3	24
Priest Upper	0	3	3	0	3	3	18

1) Number of days the presence of adult birds at the nest sites was determined 30 minutes after sunset.

Table 17. Aggressive interactions between territorial prairie falcons, conspecifics and other species, breeding season 1984.

Species	N	%
Raptorial birds		
Prairie falcon	183	38.6
Raven	165	35.0
Raven	165	35.0
Red-tailed hawk	37	7.8
Golden eagle	26	5.5
Hawk	16	3.4
Turkey vulture	10	2.1
Northern harrier	8	1.6
American kestrel	7	1.5
Great-horned owl	1	0.2
Subtotal	453	95.7
Other birds		
Rock Dove	16	3.4
Mallard	1	0.2
Subtotal	17	3.6
Mammals		
Coyote	1	0.2
Bobcat	1	0.2
Man	1	0.2
Subtotal	3	0.6

important. Therefore, 2 behavioral activities considered to be particularly important were evaluated in more detail: (1) aggressive interactions between territorial pairs and intruders and (2) daily prey delivery rates and prey composition.

Aggression

The frequency of aggressive interactions during the day showed a tendency towards a bimodal distribution (Fig. 7). The first peak occurred in the late morning (about 5 hours after sunrise) and the second peak in late afternoon and early evening (14 hours after sunrise). Prairie falcons and ravens accounted for more than 70% of all aggressive interactions between territorial pairs and intruders. A number of other raptorial birds also were attacked (Table 17). A strong positive relationship (Pearson product-moment correlation coefficient $r=0.94$, $P<0.001$) existed between frequency of attack on 8 of the most frequently attacked species and their relative abundance, as estimated by the number of occupied nest sites in the BPA (USDI 1979).

Aggression tended to increase during incubation through the second week of brood rearing, then declined (Fig. 8). This may be related to increased hunting efforts by the female during brood rearing and the increasingly longer periods of time that the nest site was unattended and not defended by either sex.

Prey Delivery Rates and Prey Composition

The diurnal distribution pattern of prey deliveries suggested a bimodal pattern (Fig. 9). A peak can be observed in the late morning and in the late afternoon-early evening. A logical explanation for this bimodal pattern would be a similar diurnal activity pattern of the main prey species of the prairie falcon, the Townsend ground squirrel (*Spermophilus townsendii*). However, activity patterns for Townsend ground squirrels could not be found in the literature, and the above hypothesis could not be tested.

Prey brought to the scrape and cached were not considered as delivered prey until recovered and consumed. Mean number of prey delivered to the scrape per day increased considerably after the chicks hatched (Fig. 10). Males provided almost all prey to the female during incubation (98.3%) and a substantial proportion of the total prey during brood rearing (78.7%). Females increased their hunting activities during brood rearing from approximately 1/5 of the total number of prey deliveries per day initially, to 1/3 towards the end of the brood rearing phase. Townsend ground squirrels and unidentified mammals (probably also ground squirrels) constituted the most important prey species for both males and females in numbers as well as biomass (Table 18).

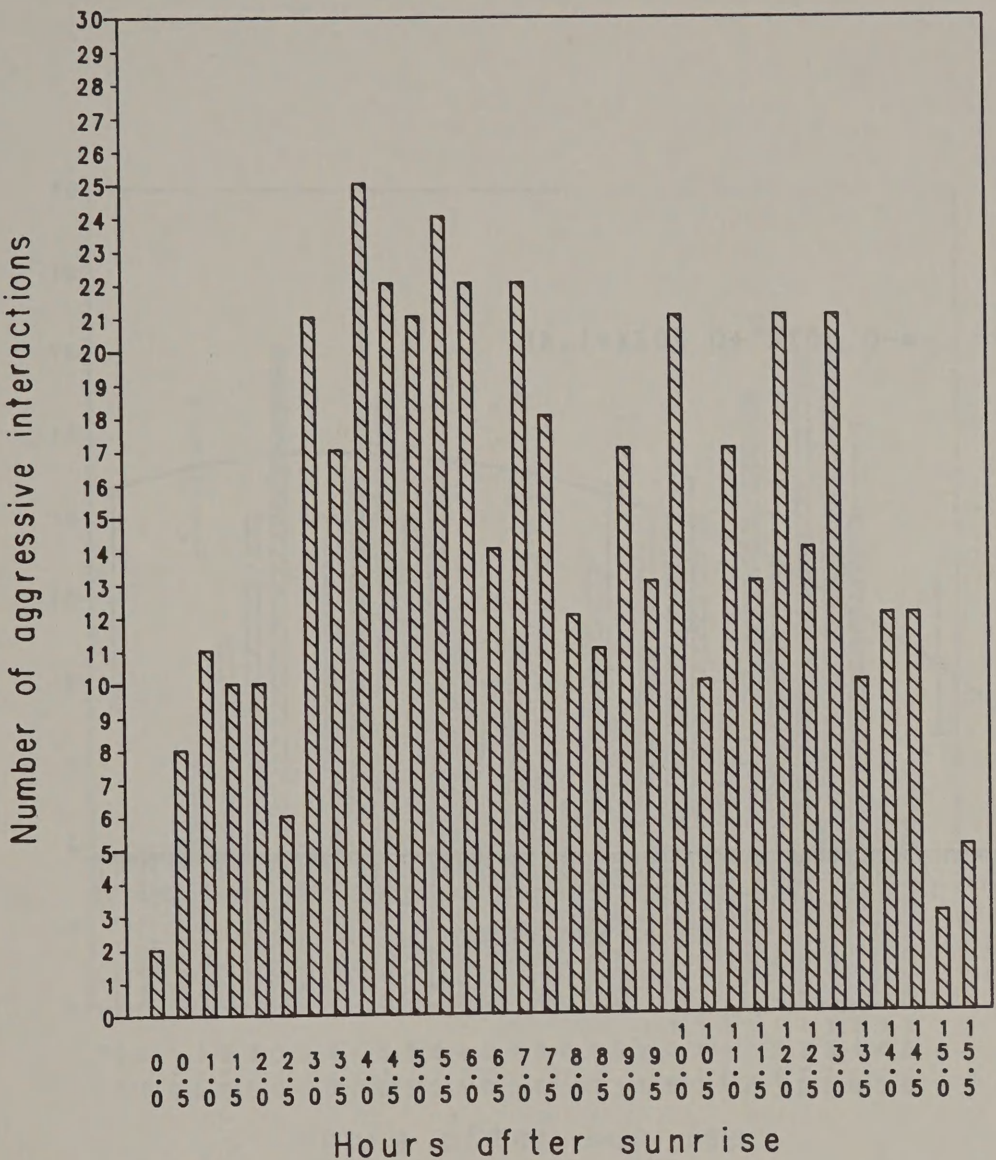

Fig. 7. Diurnal frequency distribution of aggressive interactions between territorial prairie falcons and intruders.

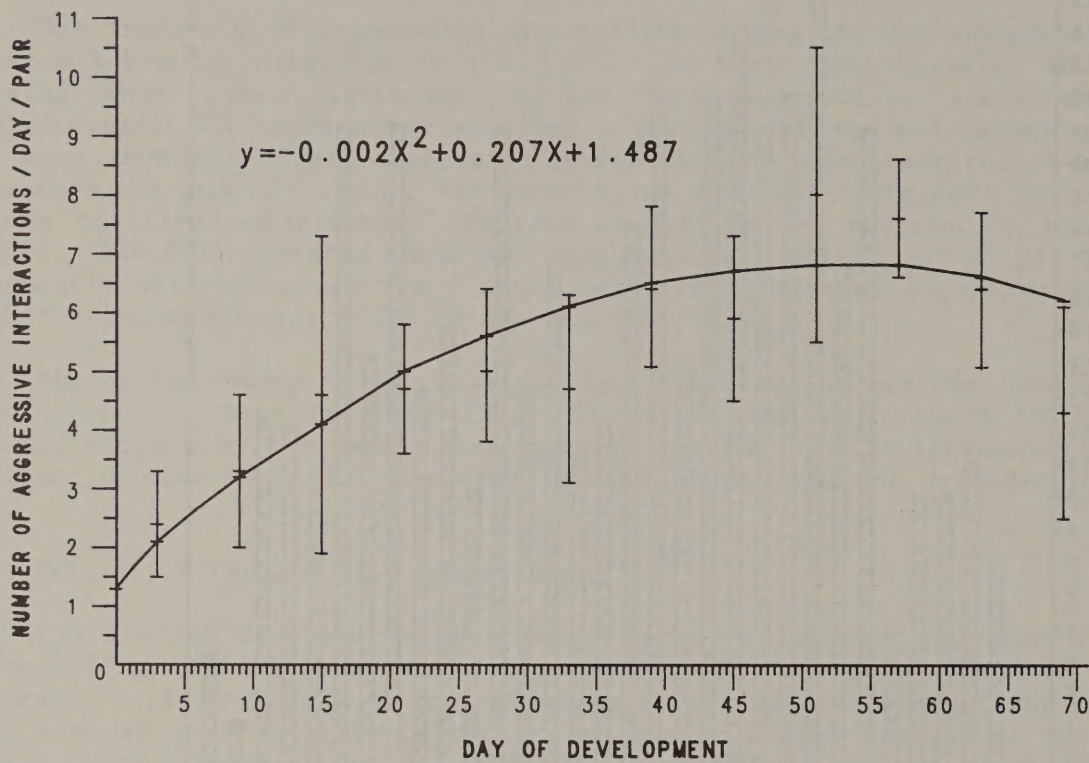

Fig. 8. Number of aggressive interactions between both sexes of prairie falcons and intruders regressed on day of development.

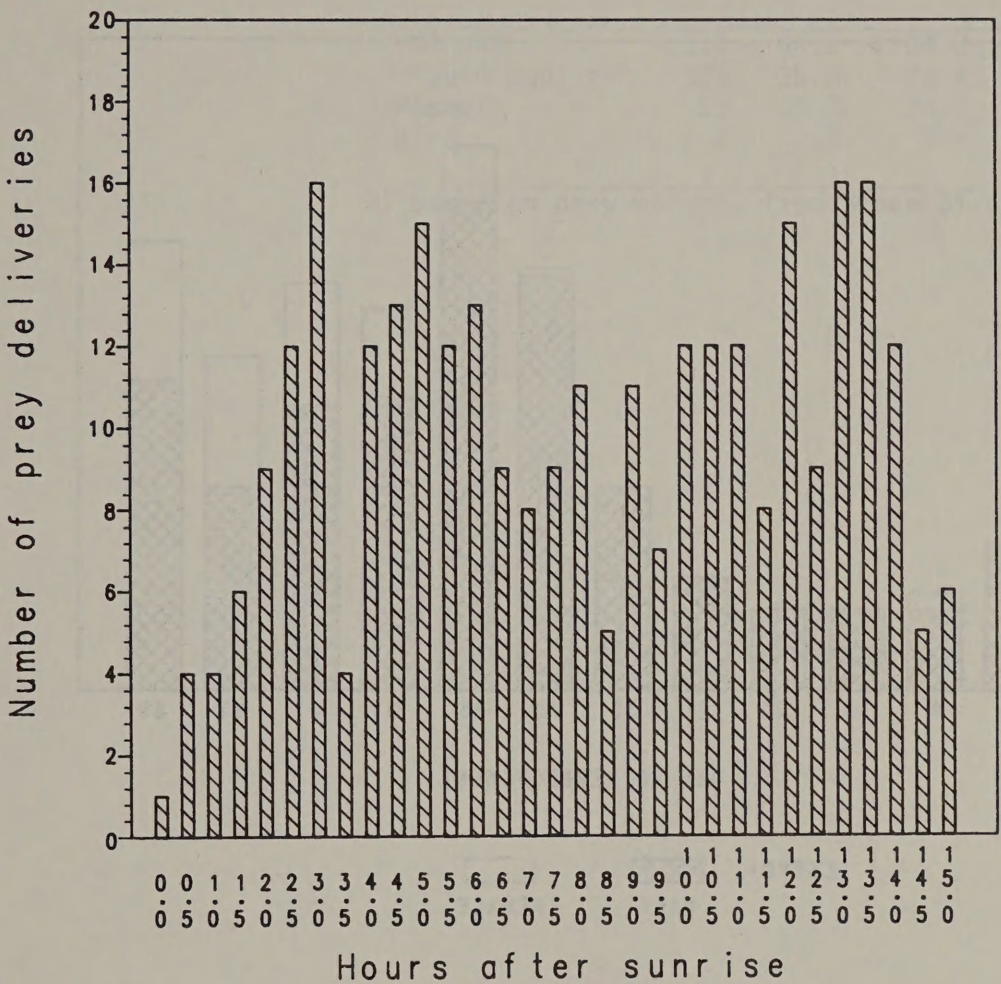

Fig. 9. Diurnal frequency distribution of prey deliveries to the scrape by both sexes of prairie falcons.

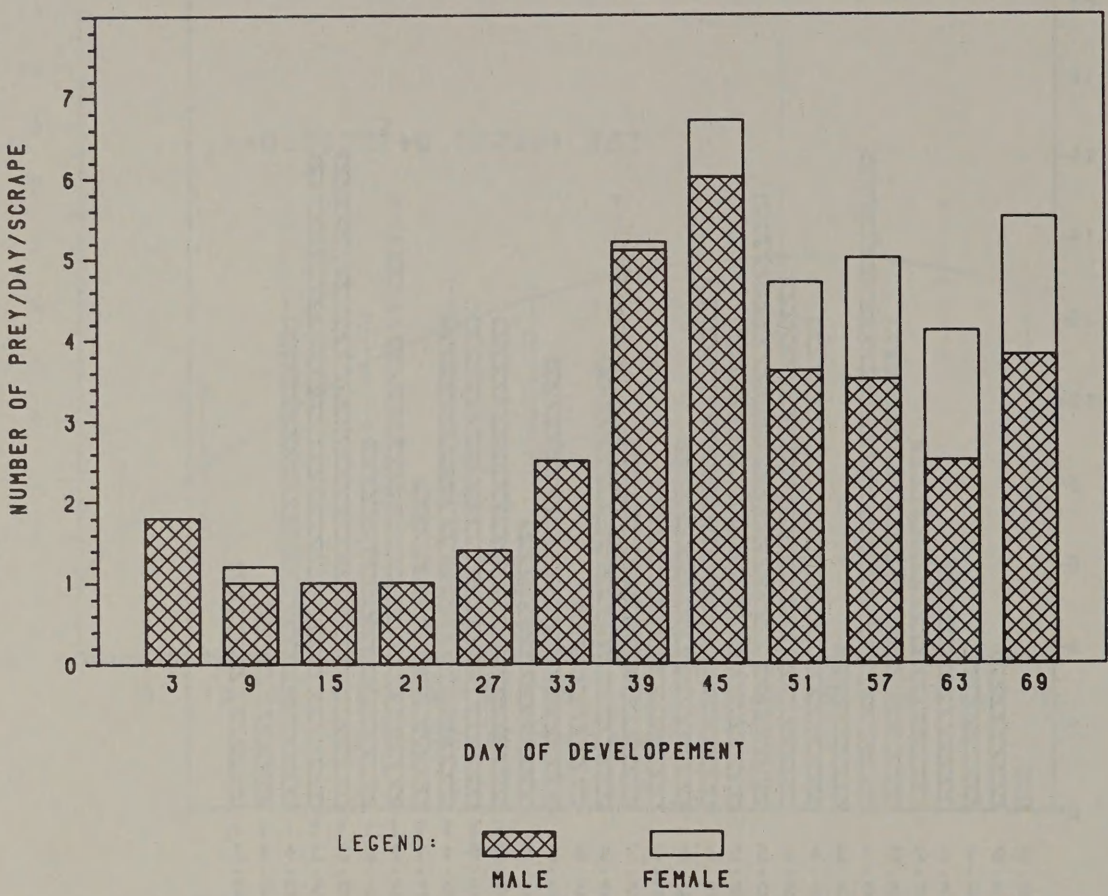

Fig. 10. Mean numbers of prey delivered to the scrape per day by both sexes of prairie falcons during the breeding season.

Table 18. Prey species brought to the scrapes by prairie falcons (male and female combined), 1984.

Species	N	%	% total biomass
Unknown	134	44.1	34.8
Ground squirrel	109	35.8	42.4
Mammal	55	18.1	21.4
Bird	6	2.0	1.4

1) Based on prey weights from Steenhof (1983).

DISCUSSION AND CONCLUSIONS

Effects of Disturbance on Prairie Falcons

Results of this study strongly suggest that disturbance as measured did not apparently influence prairie falcon behavior. However, it should be emphasized that most of the heavy road work was carried out when the prairie falcons were absent from the area. The effects of heavy construction activities during the prairie falcon breeding season only can be speculated about, but will be investigated in future years when construction activities at the Swan Falls Dam site take place year round.

Most researchers have investigated reproductive indexes in relation to disturbance variables, but have not made detailed obrelation to disturbance variables, but have not made detailed observations on behavioral changes. A study on the reproductive performance of a breeding population of prairie falcons in the Mojave desert suggested a decline in reproduction was due to habitat destruction and recreational use (Boyce 1982). In a study on breeding prairie falcons in south-central New Mexico, Bednarz (1984) suggested that mining activity may have resulted in the absence of breeding falcons in the Caballo Mountains. However, both studies are inconclusive, because possible factors causing the observed declines in breeding prairie falcons were only indirectly assessed.

Prairie falcons tend to return to previously occupied territories (Platt 1981), or their natal areas (Steenhof et al. 1984). In the treatment area, prairie falcons occupied traditional nest sites located 30-60 m above the new access road to Swan Falls. Construction of the new road changed the cliff morphology considerably (although not the actual nest sites); noise levels probably increased compared to previous years, and road work did not end until May. None of the 3 breeding pairs studied along Swan Falls access road showed aberrant behavior or nest failure which could be associated with construction work. This is not unlike reports in the literature, which demonstrate adaptability of raptorial birds to man-made environments although considerable variation exists among breeding pairs of a particular species (Newton 1979). Platt (quoted by Bednarz 1984) reported the location of a prairie falcon nest site 75 m from intensive coal mining activities. The falcons not only tolerated these condi-tions but returned in 3 consecutive years following the disturbance. Similar observations were made by Haugh (1982) on a pair of peregrine falcons nesting near a gravel excavation area where dynamite blasts occurred weekly. The falcons probably selected this nest site when excavation activities (and dynamite blasts) were in progress. In another situation gyrfalcons established their nest site close to a newly constructed airfield which was relocated from a location where these birds nested the previous year (Haugh 1982). Thus, it is possible that certain industrial activities may not necessarily stress breeding raptors.

Human disturbance as a secondary effect of industrial development, e.g., opening up of formerly inaccessible areas, may be an important detrimental factor to breeding raptors. Boyce (1982) stated that the Mojave Desert is used heavily by visitors from urban centers who engage in a variety of disturbance

activities such as shooting, off-road vehicle use, camping and hiking, which affect prairie falcon populations negatively. Haugh (1982) draws essentially the same conclusion, stating that "construction activity per se probably has little, if any, negative effect on peregrine falcons. The birds are more likely to be disturbed by human activity on or near the cliff ..". Newton (1979) states that the levels of disturbance raptors will accept are likely to vary regionally with the birds more tolerant of human presence where they are exposed to people, but not harassed or shot at. These conclusions pertain to the situation of prairie falcons at Swan Falls, because the modification of the access road has greatly facilitated access to the BPA. The opening of the World Center for Birds of Prey in Boise and the publicity the BPA is receiving may draw increasingly larger numbers of people to the receiving may draw increasingly larger numbers of people to the area. Therefore, people management will be an important aspect of managing the BPA by the BLM in future years.

Recreation

Recreational use of the study area was heavy during weekends. Recreational activities had started by early April, peaked during the Memorial Day Weekend and subsequently declined, probably due to high temperatures in the canyon. Similar conclusions were drawn in a previous recreational study carried out in the study area in 1976 (Martin 1976). In 1976, the total number of visitors was estimated at 8,700 over a 3-month period and in the present study 10,000 over the same period of time. Visitors were involved in several activities which can be considered harmful to the breeding birds in the study area, including watching birds close to the nest site, throwing rocks down the cliffs, and discharging firearms. Prairie falcons did not react immediately to gunshots or falling rocks. Small rocks often fall down the cliff through natural causes, not through human interference. The falcons did not react to people on top of the cliff as long as they were out of sight. Climbing to scrapes or walking on the canyon rim within sight provoked strong vocal reactions of the resident pair and in some cases attacks. These observations support earlier findings by Peterson and Stewart (1976) and Sitter (1983) that breeding prairie falcons react strongly to activities on top of the cliff (if in line of sight), but not as strongly at the bottom of the cliff. All cases of disturbance along the cliff edge were caused by people wandering away from the overlooks (3 and 7% of all observations in the control and treatment area, respectively). Courses of action to avoid these problems should include (1) fliers at both overlooks providing information on the birds and proper behavior of visitors (lacking now), (2) uniformed presence of BLM personnel to discourage people from indulging in unlawful practices (shooting) and to provide on-the-spot information on the BPA, especially during the weekends, and (3) limited access to roads leading along the cliff edge. Currently, these options have not been pursued vigorously although these suggestions were stated in an earlier recreational study of the BPA (Martin 1976).

Aspects of the Biology and Ecology of Prairie Falcons

Although reproductive parameters, nesting chronology and food of the prairie falcon have been well described (Enderson 1964; Evans 1982; Ogden and

Hornocker 1977; Sitter 1983; USDI 1977, 1979, 1980, 1981), many aspects of the breeding biology of the prairie falcon have been reported only in qualitative terms. This study has provided detailed information on the daily time budget of male and female prairie falcons, aggressive interactions between prairie falcons and other birds and prey, prey delivery rates during incubation and brood rearing by both sexes. Decker and Bowles (1930), Bent (1938) and Enderson (1964) contended that female prairie falcons do most of the incubation and males do all of the hunting for both sexes during the incubation period. In this study, males spent on the average 21% of the day incubating while females were hunting or feeding; females incubated 68% of the day. Kaiser (in Haak 1984) reported that males incubated 22% of the observation time and females 74% of daylight hours (N=105 hours); only females incubated at night. In this study chicks were brooded during the day by both sexes up to their third week, but the percent brooding decreased over time (Fig. 6); females brooded on the average 20% and males 10% of the day. Males hunted 33% of the day during incubation and delivered prey to the female. However, females also hunted during incubation (7% of the day). Both sexes increased their hunting activities during brood rearing. Males perched and preened longer during incubation than females (9 and 6%, respectively). During brood rearing females spent long periods perched near the nest site. On the average, males spent 26% of the day perched near the nest site and females 32%.

Newton (1979) divided incubating raptors into three groups based on the division of incubation between the sexes and prey supplied to the female by the male. Only females incubated in supplied to the female by the male. Only females incubated in the first group; in the second group males incubated when the female fed on prey supplied by the male. The males did all the hunting, and only females incubated by night in both groups. In the third group incubation was shared equally by both sexes, and the female also foraged. The prairie falcon apparently falls between the second and third group. The brood rearing phase was described by Newton (1979) as consisting of three broadly overlapping phases. First, after hatching the female is committed to brooding and does not hunt. Gradually the female spends less time brooding but remains close to the nest and feeds the chicks. Later when the chicks are larger and better able to regulate their own temperature, the female also starts to hunt. This general pattern also could be observed with the prairie falcon (Fig. 6). There were some differences, however. Females hunted from the onset of the brood rearing stage and increased their hunting over time. Males increased their hunting efforts during brood-rearing, and spent some time brooding.

Aggression

Bent (1938) and Sitter (1983) stated that prairie falcons are particularly tenacious in their territorial defense. Sitter (1983) reported, but did not provide supporting data, that as the breeding season progressed territories appeared to break down and aggression between adults decreased. Then, when young fledged, territorial aggression would be renewed. However, in this study aggression increased during the breeding season until both sexes hunted, and the nest site was undefended at times.

After conspecifics, ravens were the most frequently attacked species. Bent (1938) commented on the apparent close association between prairie falcons and ravens at the nesting sites. Similar observations were made between peregrine falcons, gyrfalcons and ravens (Cade 1960; White and Cade 1971). The high level of interaction between prairie falcons and ravens in this study would attest for a more antagonistic relationship instead of a relatively unaggressive coexistence between the species (Bent 1938). Ravens and prairie falcons may prefer similar nesting sites (and prey?) and end up as close neighbors.

RECOMMENDATIONS

In future studies the same sampling scheme and behavioral categories can be used. Two important recommendations concern the measurement of disturbance. First, it is recommended that the scope of the current study be expanded to include controlled disturbance manipulations with nesting prairie falcons in subsequent years. Second, since recreational activities may be important as a secondary effect of industrial activities, future studies should include sampling schemes to monitor the presence and activities of visitors in greater detail. Furthermore, it is recommended that uniformed BLM personnel patrol the BPA at Swan Falls and the control area during weekends from early April until June to provide information for visitors and restrain people from unlawful practices. Also, field personnel (hired by BLM) are located in blinds just below the overlooks and may become unwilling targets of stray ammunition.

Acknowledgments-- A large number of people made this study possible. Special thanks go to Allan R. Ansell, Environmental Studies Coordinator, Environmental Affairs Department, Idaho Power Company, and Michael N. Kochert, Leader Birds of Prey Research Project, Bureau of Land Management, Boise District, who laid the groundwork for this timely study. Karen Steenhof and Leonard Young, Bureau of Land Management, Boise District, were especially helpful in appropriate criticism of the study, advice and logistical support. The cooperation and friendship we experienced from Idaho Power personel stationed at Swan Falls, particularly of Gene and Wilma Adsmond and the Bergh family, made our stay in the Clubhouse enjoyable. The hospitality of Allan and Conny Ansell during my stay in Boise was much appreciated. The help and expertise of Gary D. Blankenship, Linda J. Stewart, and Kevin J. Dugan, Idaho Power Computer Information Center, is gratefully acknowledged. The Biology Department of the Virginia Polytechnic Institute and State University, Blacksburg, Virginia, is acknowledged for providing access to the University's computer system for data analysis. Dr. W. Carter Johnson was particularly instrumental in making this arrangement. Dr. Gary Nunn, Department of Computer Science, advised me on statistical matters.

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APPENDIX I. Construction activities at the Swan Falls access road from October 1983 through May 1984.

	1983									1984								
	October			November		December				January			February		March		Apr	May
Construction activity	17-21	24-28	31-3	7-12	14-19	21-26	28-2	5-9	12-16	9-13	16-20	23-27	13-17	20-24	15-17	19-23	2-4	31
Surveying	++++++	++++++	++++++	++++++	++++++	++++++	++++++	++++++	++++++	++++++								
Equipment moved in	++++++	++++++	++++					+++						+++++	+++++			
Earthwork		++++	++++++	++++++	++++++	++++++	++++++	++++++	++++++	++++++	++++++	++++++						
Culverts					++++++				+++++				++++					
Drilling and blasting					++++++	++++++	++++++	++++++	++++++	++++++	++++++	++++++		+++++				
Guard rail										++++++	++++++	++++++	++++++					
Crushed rock stockpile											++++++	++++++						
Paving															++++++	++++++	++++++	++++

APPENDIX II

Definition Behaviors

Prey delivery: delivery of prey item to the scrape
Prey species: abbrevation common name or category (mammal, bird, reptile, other).
Feeding: feeding young, feeding adult.
Incubation: lie posture covering the eggs.
Brooding: sheltering the chicks. Nest visit: adult entering the scrape for less then 1 min.
Resting/sleeping/perching: inactively perching, no head or body movements.
Preening: cleaning, oiling, positioning feathers.
Copulation
Flying-in-canyon: flying within sight in or above the canyon.
Flying-out-of canyon (hunting): flying out of sight out of the canyon; this category was used when the bird left the canyon and returned with prey or showed other indications that the bird had hunted. Unattended: eggs or chicks are left unattended by adults.

Inter- and Intraspecific Interactions

Vocalization: alarm call, lowest level of aggression.
Aggressive: stooping, chasing, following of intruder.
Non-aggressive: mutual display, soaring, no overt aggression.
Defensive: avoidance, flying directly away.

APPENDIX III. Yearly occupancy of prairie falcon nest sites in the control and treatment areas in the BPNA.

Nest site	Year											
	73	74	75	76	77	78	79	80	81	82	83	84
Treatment area												
Balls Basin Powerline	2	-	2	41	41	41	41	-	2	1	1	1
Falcon Flats Fingers	2	-	-	42	42	3	1	1	2	2	2	41
Ferry	2	-	-	4	2	1	-	1	2	-	1	41
Swan Dam Road Turn	2	4	-	41	2	2	2	-	-	1	4	41
Swan Dam North Side	2	-	4	4	4	4	2	4	-	2	3	41
Swan Dam Three Poles	-	41	2	41	1	1	42	3	2	42	42	42
Control area												
Beecham	2	4	-	-	2	1	2	-	1	1	1	1
Beecham Gate	-	-	4	3	-	4	2	4	2	2	2	1
Beecham Gate Dwnstr	-	-	2	3	-	1	1	1	1	1	1	1
Camera	4	-	41	3	42	3	41	41	4	4	2	41
Dedication Point	2	-	3	3	2	2	4	2	4	2	4	41
Dedication Site	2	4	4	2	3	2	2	4	3	4	42	1
PF I	2	2	41	4	41	2	1	1	2	42	41	41
PF II	2	-	41	4	41	2	1	42	2	2	1	41
Priest Lower	2	41	4	1	1	42	42	-	-	2	-	1
Priest Rapids I	2	2	2	4	2	4	2	1	2	-	-	42
Priest Rapids II	-	-	2	3	2	2	2	2	-	4	-	3
Priest Upper	2	41	4	4	41	4	2	2	4	4	2	41
Priest Upper	2	41	4	4	41	4	2	2	4	4	2	41

1) Unpublished data Bureau of Land Management, Birds of Prey Research Project, Boise.
2) Coding occupancy:
 1=vacant
 2=occupied undetermined breeding
 3=breeding undetermined success
 41=breeding successful
 42=breeding unsuccessful
3) Only in the years 1976, 1977, and 1978 the 2 study areas were completely surveyed and were used to calculate occupancy rates.

TITLE: Feeding Ecology of the Common Barn-Owl in the Snake River Birds of Prey Area.

INVESTIGATOR: Carl D. Marti, Department of Zoology, Weber State College, Ogden, Utah 84408.

OBJECTIVES:

1. Determine food habits and other food niche parameters of nesting common barn-owls (*Tyto alba*).

2. Determine food niche variation (a) among sites and (b) among years.

3. Determine the barn-owl's position in the raptor feeding guild.

INTRODUCTION

Field studies for this project began in 1978 and have continued through 1984. All data were obtained in the Snake River Birds of Prey Area (SRBPA) which is described in U.S.D.I. (1979). Analysis and subsequent statistical treatments were done at Weber State College, Ogden, Utah. Reports on previous years are also available (Marti 1979, 1981, 1982, 1983).

This report describes field activities and preliminary analysis for 1984 data and presents 1984 dietary trends in relation to 1983 diets.

ANNUAL REPORTS

Three visits were made to the SRBPA to collect data in 1984: 20-22 April, 26-28 May and 1-7 July. Thirty-three samples of regurgitated pellets were collected from 19 sites (Table 1). A summary of the prey content of these pellets is in Table 2.

Microtus increased 10.6% and *Peromyscus* 1.4% by number in the total barn-owl diet sample from 1984 over 1983. Other major mammalian genera declined overall as barn owl prey during this time (*Mus*, -4.2%; *Perognathus*, -2.5%; *Dipodomys*, -2.1%; and *Thomomys*, -0.8%). Birds also dropped by 1.3% in 1984 compared to 1983. *Microtus* increased as prey at all 16 collection sites where data were available in both 1983 and 1984; *Peromyscus* increased at 10 sites. *Dipodomys* decreased in diets at all 16 sites, *Perognathus* and *Mus* decreased at 14, and *Thomomys* decreased at 11. Birds also declined at 11 sites.

PLANS FOR 1985

Three trips to the SRBPA are planned for the spring/summer of 1985. The primary objective is to continue collecting food habits data for the analysis of long-term predation trends by barn-owls.

Table 1. Sites where common barn-owl food habits data were collected in the SRBPA, 1984.

Castle Rock (3 sites)
Can-Ada
Chattin Hill
Fence Corner (2 sites)
Garbage Draw
Jensen Cliff
Kitten's
Lower Lower Black Butte (2 sites)
Mary's
Road End
Upper Lower Black Butte (4 sites)
Wildhorse Butte, SW

Table 2. Total prey identified for the common barn-owl in the SRBPA 1984.

Prey Species	Number	Percent Number
MAMMALS		
Antrozous pallidus	1	tr.*
Sorex vagrans	41	0.5
Mus musculus	294	3.9
Peromyscus spp.	947	12.7
Reithrodontomys megalotis	201	2.7
Onychomys leucogaster	3	tr.
Neotoma lepida	26	0.3
Neotoma cinerea	14	0.2
Microtus montanus	4,872	65.2
Perognathus parvus	357	4.8
Dipodomys spp.	294	3.9
Thomomys townsendi(juvenile)	354	4.8
Spermophilus townsendi	1	tr.
unidentified leporids (neonate)	17	0.4
BIRDS		
Sturnus vulgaris	6	0.1
Porzana carolina	2	tr.
unidentified icterid	11	0.1
unidentified medium bird	5	0.1
unidentified small bird	36	0.5
unidentified scorpion	1	tr.
TOTALS	7,475	100.0

* Less than 0.1%.

ACKNOWLEDGMENTS

I thank Michael Kochert, Karen Steenhof, John Doremus, Lenny Young and all of the Snake River Birds of Prey Research staff for a variety of assistance in carrying out this study. The Bureau of Land Management provided a vehicle for field use and living space in field camps. Thanks also to Weber State College for providing a Faculty Research Grant covering travel to the study area from Ogden, Utah, and laboratory space and computer facilities for data analysis.

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TITLE: Productivity, Nest Site Characteristics, and Food Habits of Long-eared Owls in the Snake River Birds of Prey Study Area.

COOPERATOR: Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, Montana 59812.

INVESTIGATOR: Jeffrey S. Marks

OBJECTIVES:

1. To determine the nesting density and annual production of long-eared owls in the BPSA.
2. To determine the influence of nest site characteristics on the nesting success of long-eared owls.
3. To determine the food habits of nesting long-eared owls.

RESULTS

Jeff Marks completed a thesis entitled "Nest site characteristics, reproductive success, and food habits of long-eared owls in southwestern Idaho" in fall 1984. The thesis was completed under the direction of Dr. Riley McClelland in partial fulfillment of the requirements for a Master of Science degree in Wildlife Biology at the University of Montana.

ABSTRACT

Nesting biology of long-eared owls (Asio otus) was studied in the Snake River Birds of Prey Area in southwestern Idaho from March through July in 1980 and 1981. One hundred and twelve nesting attempts were recorded for 104 pairs of owls. All nests were in trees in old stick nests built by corvids. Discriminant function analysis identified nest diameter and nest height as the variables that best separated owl nests from unused corvid nests. Nests selected by owls tended to be higher and wider than unused nests. Using nests found during incubation, nesting success was 34% in 1980 and 51% in 1981. The minimum number of young fledged per successful nest averaged 3.4 in 1980 and 4.0 in 1981. Most nesting failures were caused by predation. Unsuccessful nests tended to be closer to water and thus more accessible to raccoons (Procyon lotor) than were successful nests. Four owls banded as nestlings and later captured as breeding adults nested successfully within 1.5 km of their natal nests. Analysis of pellets yielded 4,208 prey items. Small mammals constituted over 98% of the diet, with 5 genera (Peromyscus, Perognathus, Dipodomys, Microtus, Reithrodontomys) accounting for 94% of all prey by number and 91% by biomass in each year. Estimated mean weight of mammalian prey was 31 g, and 98% of the mammalian prey weighed less than 60 g. Compared with other North American studies, the owls in this study had a wider feeding niche and preyed more extensively on non-microtine rodents. Interlocality differences in the long-eared owl feeding niche probably reflected differences in the composition of small mammal faunas.

Long-eared owls in this study appeared to feed opportunistically; prey size, rather than prey type, was the most important factor in food selection. Common barn-owl (Tyto alba) pellets collected by Carl Marti in 1980 and 1981 allowed comparison of the 2 owl species' feeding niches. Dietary overlap between the 2 species was 48.4% in 1980 and 60.9% in 1981. Nesting barn-owls were more closely associated with irrigated agriculture than were long-eared owls, and in both years barn-owls had greater proportions of Microtus in their diets than did long-eared owls. The mean weight of barn-owl prey was heavier than that of long-eared owl prey. Differences in habitat use, food-niche breadth, and prey size are potentially important coexistence mechanisms for the two species.

TITLE: Nest Defense and Human Habituation in Nesting Red-tailed Hawks (Buteo jamaicensis)

INVESTIGATORS: Marc J. Bechard, Department of Biology
Boise State University, Boise, Idaho 83725

OBJECTIVES:

1. To determine the aggressiveness of nest defense behavior shown by red-tailed hawks nesting in Idaho during the 1984 breeding season.

2. To determine the levels of human activity in the vicinity of nests used by red-tailed hawks.

3. To determine if human activity alters defensive behavior of red-tailed hawks toward human intruders at nest sites.

INTRODUCTION

The red-tailed hawk (Buteo jamaicensis) has been reported to react differently to human intrusions at nest sites in various parts of North America (Orians 1955). Apparently, in the east, where settlement occurred first and exposure to humans has been longest, red-tailed hawks have habituated (defined as the waning of a response to a repeated behavior) to people, and in so doing, they have lost their aggressiveness, making them more susceptible to nest predation from humans and wildlife (Lee 1981). This study was undertaken as part of a larger study in West Virginia, Wisconsin, Colorado, Washington, California, and Saskatchewan to determine if the defense response of red-tailed hawks to humans does in fact vary across North America and if the intensity of the response is related to exposure to humans.

This report describes field observations which were made during the 1984 breeding season in and near the Snake River Birds of Prey Area, Idaho.

ANNUAL REPORT

To be compatible with the other component studies, tree nests were selected for observation (Table 1). Each nest was approached by a lone observer; defense calls and dives were counted while the observer was at the base of the nest tree and at the nest itself for 10 and 5 min periods, respectively. Defense responses are summarized in Table 2. The amount of human activity in the vicinity of each nest was also measured by recording from maps the proximity of buildings and roads to the nest tree (Table 3).

Red-tailed hawks nesting in southwestern Idaho did not appear to be aggressive. Few birds dove at observers, and seldom did a hawk approach to within 5 m. The intensity of the defense response did not appear to be related to the number or proximity of roads or buildings within the nest area.

Table 1. Hawk nest sites studied in and near the Snake River Birds of Prey Area during 1984.

Red-tailed Hawk	Nesting Substrate
King Ranch	Tree
Foreman Reservoir	Tree
Castle Road Tree	Tree
Picket Creek #1	Tree
Picket Creek #2	Tree
Oreana Church	Tree
Spring Draw	Tree
Bruneau City	Tree
Shoofly Ranch	Tree
Jack's Creek	Tree
Jensen Tree	Tree
Gabica	Cliff
Swainson's Hawk	
Tree House Nest	Tree
Kuna-Mora Road	Tree
Grandview Tree	Tree
Castle Creek	Tree
Melba Nest	Tree
Nampa Nest	Tree

Table 2. Nest defense of red-tailed hawks breeding in and near the Snake River Birds of Prey Area during 1984. Observations at the base of the nest tree and at the nest itself were made for 10 and 5 min, respectively. Distance measurements are in meters.

Nest Site	Base of Nest Tree			At Nest		
	Closest Distance	No. Calls	No. Dives	Closest Distance	No. Calls	No. Dives
King Ranch	20	54	0	10	27	1
Foreman Reservoir	60	61	0	15	44	0
Castle Road Tree	25	85	0	15	30	0
Picket Creek #1	25	70	0	15	23	2
Picket Creek #2	20	17	0	5	43	6
Oreana Church	20	24	0	2	15	7
Spring Draw	25	85	0	10	46	2
Bruneau City	20	49	0	7	29	2
Shoofly Ranch	25	85	0	10	37	1
Jack's Creek	15	21	0	3	43	3
Jensen Tree	35	15	0	--	--	-

Table 3. Measures of human activity in the vicinity of red-tailed hawk nests in and near the Snake River Birds of Prey Area during 1984. Numbers in parentheses are the number of roads or buildings within a 1 km radius of the nest.

Nest Site	Distance to Nearest Paved Road (m)	Distance to Nearest Unpaved Road (m)	Distance to Nearest Building (m)
King Ranch	6 (1)	300 (1)	500 (2)
Foreman Reservoir	200 (1)	750 (1)	500 (2)
Castle Road Tree	750 (1)	350 (1)	500 (4)
Picket Creek #1	1000 (1)	50 (1)	300 (9)
Picket Creek #2	1000 (1)	150 (1)	300 (9)
Oreana Church	300 (1)	300 (1)	350 (13)
Spring Draw	1000 (1)	100 (1)	600 (2)
Bruneau City	200 (1)	50 (1)	500 (2)
Shoofly Ranch	2 (1)	30 (1)	100 (3)
Jack's Creek	5 (1)	35 (1)	200 (3)
Jensen Tree	800 (1)	2 (3)	5 (7)

A paper based on data collected during 1983-84 in West Virginia, Wisconsin, Colorado, Idaho, Washington, California, and Saskatchewan is being prepared for publication.

Incidental to this study, the Gabica red-tailed hawk nest was also observed. Instead of the usual tree nest, in 1984 the nest was built on a cliff. It contained 3 eggs, all of which hatched. When the nestlings were approximately 15 days of age, 2 nestlings of approximately the same age that had been turned in to the Boise Zoo were fostered into the nest. All 5 young were banded. The nest was observed weekly after fostering; all 5 birds fledged from the nest.

To obtain data on the breeding population of Swainson's hawks (*Buteo swainsoni*) in and near the Snake River Birds of Prey Area, nests of this species were also located during 1984. A total of 6 nesting attempts was found in May, and in July, trees were climbed to band young. Of the 6 nests, only 2 were successful. Four young were produced for a success rate of 0.67 young per nesting attempt. Two of the four birds which fledged were banded.

ACKNOWLEDGMENTS

I thank Michael Kochert, Karen Steenhof, Leonard Young, John Doremus, Keleigh Hague, Eric Olsen, and Duane Porter for assistance in carrying out this study. Thanks also to Boise State University for providing a Faculty Research Grant to fund field assistants.

LITERATURE CITED

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Orians, G. 1955. Breeding biology of red-tailed hawks in Wisconsin. Condor 57:45-59.

TITLE: Use of Nest Boxes, Reproduction, and Food Habits of Western Screech-Owls in the Snake River Birds of Prey Area.

INVESTIGATORS: John Doremus, Wildlife Biologist
Jeffrey Marks, Biologist

OBJECTIVES:

1. Monitor the use of artificial nest boxes by western screech-owls.
2. Determine reproductive success and food habits of screech-owls at these sites.

METHODS

At present, 2 nest boxes have been placed in trees at each of 21 sites in the Snake River Birds of Prey Area. In 1984, boxes were checked at 13 sites at irregular intervals throughout the year. Data were gathered on occupancy and nesting success, adults and nestlings were weighed and banded, and pellets and prey remains were collected for analysis of food habits.

RESULTS

During part of the year, at least 1 adult western screech-owl (Otus kennicottii) was present at each of the 13 sites. During the breeding season, 3 sites (23.1%) were vacant. Three (23.1%) were occupied, but breeding was not confirmed. Breeding was confirmed, but success was unknown at 4 sites (30.8%); 2 sites (15.4%) were successful, and 1 site (7.6%) failed. Nineteen nestlings were banded at 5 sites ($\bar{x}$ = 3.8 young/site), and 9 adults and 1 owl of unknown age also were banded. Pellets and prey remains were collected at 8 sites and will be analyzed early in 1985.

Since 1980, 36 screech-owls have been banded (20 nestlings, 16 HY or AHY). Three owls banded in late fall 1983 bred at their respective banding sites in 1984 and were still present during fall 1984. No nestlings have been recaptured as adults, and no adults have been recaptured more than 200 m from the site where they were banded.

Since 1983, 27 weights have been obtained from 13 full-grown screech-owls ($\bar{x}$ = 217.8 g, SD = 33.5 g). The weights of 2 adult females peaked during the egg-laying period, whereas the weight of an adult male was relatively constant from January to May (Table 1). The weight of an owl of unknown sex was highest in November (Table 1).

Table 1. Weights of 4 adult western screech-owls weighed at least 3 times during 1984.

Band No.	Sex	Date	Weight (g)
795-43962	F[1]	15 January	182
		20 February	225
		15 March	268
		15 May	224
		7 November	225
795-43964	F[2]	15 January	215
		15 March	300
		7 May	195
795-43965	M[2]	15 January	200
		15 March	208
		7 May	184
795-43966	Unk	15 January	200
		20 February	238
		15 March	208
		7 November	265

[1] 795-43962 was larger in weight, wing chord, and tail than her mate, and probably was a female.

[2] 795-43964 was captured during incubation; 795-43965 was her mate.

PLANS FOR 1985

In 1985, efforts will be directed toward obtaining complete data on occupancy, nesting success, and productivity at 15 sites. At least 10 occupied sites will be visited no less than once each month to weigh banded adults and collect pellets and prey remains. Banded adults will be sexed during the breeding season, and all nestlings will be banded.

TITLE: Utilization of Artificial Nesting Platforms by Raptors in and Near the Snake River Birds of Prey Area.

INVESTIGATORS: Mark A. Hilliard, Wildlife Biologist, Bruneau Resource Area.
Randy M. Trujillo, Wildlife Biologist, Bruneau Resource Area.
John H. Doremus, Wildlife Biologist, Bruneau Resource Area.
Carla D. Schroer, SCA Volunteer.
William M. Iko, SCA Volunteer.

OBJECTIVES:

1) To assess utilization of artificial nest platforms by nesting raptors.

2) To record reproductive information at each occupied structure.

METHODS

Thirteen of 14 artificial nesting platforms (Howard and Hilliard 1980) in or near the Birds of Prey Area were inspected at irregular intervals from the ground from early March to late June. An additional platform was inspected once from a helicopter during the March nesting survey conducted for the PP&L nesting study. Number of visits to each site ranged from 1 to 14.

RESULTS

Fourteen platforms were intact in 1984, and 9 were used by 8 ferruginous hawks (*Buteo regalis*) and 1 red-tailed hawk (*B. jamaicensis*) pairs. All 9 pairs laid eggs. The red-tailed hawk pair fledged 2 young, and 6 ferruginous pairs successfully fledged young. Success was not determined at the other 2 ferruginous hawk sites. Complete fledge counts were made at 4 sites which averaged 3.25 young fledged per attempt.

LITERATURE CITED

Howard, R. P., and M. Hilliard. 1980. Artificial nest structures and grassland raptors. Raptor Res. 14:41-45.

TITLE: Assessment of Potential Bald Eagle Nesting Habitat: Hell's Canyon Reach of the Snake River.

INVESTIGATORS: Kent Woodruff, Wildlife Biologist
Georgia Schubilske, Biological Technician (Fisheries)
Karen Steenhof, Analytical Wildlife Research Biologist
Leonard Young, Analytical Wildlife Research Biologist

COOPERATORS: U.S. Department of the Interior, Bureau of Land Management, Vale District, Baker Resource Area

OBJECTIVES:

1. To assess the potential of the Hell's Canyon Reach of the Snake River as bald eagle nesting habitat.

   a. To accurately estimate the number of nesting pairs that this area could support.

   b. To determine the specific locations most suitable for nesting.

2. To develop a quantitative method for evaluating potential bald eagle nesting habitat.

INTRODUCTION

Managers are often faced with large amounts of habitat and limited resources for protection or enhancement. They must often decide which specific areas should be protected and which may be developed for other uses. Choices must often be made quickly and frequently involve large areas. It is often impractical to conduct a full-scale research effort over a period of years, yet resource-correct decisions must be made.

The draft Pacific Bald Eagle Recovery Plan identifies the Hell's Canyon Reach of the Snake River as potential bald eagle nesting habitat. However, this decision was not based on systematically-collected data but rather on general knowledge of the area and occasional sightings of eagles during the breeding season. Furthermore, specific areas along this stretch of river which may be suitable for nesting were not identified. This makes it difficult to accurately estimate the number of nesting pairs the area could support.

The goal of this study is to develop a quantitative method of habitat assessment, using the Hell's Canyon Reach of the Snake River as a test case, which can be applied to any potential bald eagle nesting habitat situation. We employed methods, and adopted levels of resolution, that could be quickly and easily applied over a large area by personnel with only basic training in biology yet would yield data of sufficient quality to permit sound management decisions.

METHODS

The Snake River between the western tip of Porter's Island, 12 km west of Weiser, Idaho, and Hell's Canyon Dam was divided into 15, 10-km segments. Habitat features of importance to nesting bald eagles were evaluated for each segment.

Nest Sites

Tree stands within 2 km of the river channel were identified from 1:31,000 aerial photographs, measured via electronic planimetry of 1:24,000 orthophotographic quadrangles, and classified into 6 categories: 1) overstory consisting of large trees (>53 cm dbh) with low density (<40% crown closure), well-developed understory present, 2) overstory consisting of large trees with moderate to high density (>40% crown closure), well-developed understory present, 3) overstory consisting of large trees with low density, poorly-developed or no understory, 4) overstory consisting of large trees with moderate to high density, poorly developed or no understory, 5) overstory consisting of small (<53 cm dbh) trees, and 6) riparian stands with trees suitable for bald eagle nesting. U. S. Department of Agriculture, Forest Service inventory data were used to help classify tree stands occurring on Forest Service administered lands. Accuracy of classification was field-checked during a 13 September helicopter flight.

Cliffs within 2 km of the river channel that were at least 20 m in height and had at least 125% slope were identified and measured via electronic planimetry of 1:24,000 orthophotographic quadrangles. Cliffs were field-checked for ledges that were sufficient to support a bald eagle nest and inaccessible to mammalian predators.

Food

From 23 July to 23 August, fish were sampled at 3 randomly selected points within each segment. Sample points were at least 1 km apart. At each point a 20 x 1.5 m variable mesh (1.3-6.3 cm) gill net was set perpendicular to the shoreline. Nets were set in late afternoon to early evening, fished overnight, and pulled in early to mid-morning. Species, length, and weight of all fish caught were recorded. During the same period, boat transects were run to survey fish carrion. The boat was run at 8 km/hour, 30 m from shore, paralleling the entire 20 km shoreline of each segment. Surveys were conducted in late afternoon to early evening. Species, estimated length (nearest 5 cm), and estimated distance from the transect center line (nearest 1 m) were recorded for each fish. At 5 points within each segment, counts of fish rises were made during a 5-min period. The first point was randomly selected, and the 4 subsequent points were spaced at 500 m intervals downstream. All rises within an estimated 100 m of an observer standing on shore were counted and classified as carp or other fish. Counts were made in late afternoon to early evening.

Water samples were collected at 3 randomly selected points within each segment. Sample points were at least 1 km apart. At each point 500 ml of

water was collected in midstream, 25-35 cm below the surface. All water samples were collected on 7 August. Samples were analyzed in the laboratory for total dissolved solids (mg/l), as an index to primary productivity, and turbidity (FTU), as a measure of water clarity.

Suitable perches within 50 m of the shoreline were identified during boat surveys of each segment. Perches were classified as: 1) trees, 2) cliffs and rocky outcrops, and 3) other (utility poles, fenceposts, etc.). Results were tabulated by 1-km unit within segments to examine distribution of suitable foraging perches.

Human Activity

Semi-permanent habitat alterations within 2 km of the river channel were identified from 1:31,000 aerial photographs and 1:24,000 orthophotographic quadrangles. Numbers of buildings, dams, bridges, boat ramps, and campgrounds, and km of interstate highway, paved road, gravel road, jeep trail, transmission line, and railroad track were measured for each segment.

Between 7 July and 13 August, each segment was surveyed 4 times to quantify human activity. Two surveys were conducted on weekdays and 2 on weekends. Each observed activity was described, and locations were plotted on 1:24,000 topographic quadrangles.

RESULTS

Data have not yet been analyzed. We plan to develop a model incorporating all habitat variables that can be used to compare potential of specific areas (i.e., segments) within the overall area of concern.

ACKNOWLEDGMENTS

We thank personnel of the Wallowa-Whitman and Payette National Forests, particularly Dorothy Terry, for assistance in classifying tree stands. Oregon Department of Fish and Wildlife personnel were helpful in providing background information on fish populations in the study area. Alan Sands and Sam Mattise, Bureau of Land Management, Boise District, and Matt Kniesel, Bureau of Land Management, Vale District, contributed advice and logistic support.

TITLE: The Occurrence of Vesicular-Arbuscular Mycorrhiza Associated with Desert Shrubs.

COOPERATOR: Department of Biological Sciences, Boise State University

INVESTIGATORS: Marcia Wicklow-Howard, Principal Investigator
Tina Bell, Research Assistant
Sonia Caldwell, Research Assistant
William Scott, Research Assistant

OBJECTIVES:

1. To document the seasonal occurrence and qualification of vesicular-arbuscular mycorrhiza in the major shrub species studied at the BPNA.

2. To determine the occurrence of vesicular-arbuscular mycorrhiza in *Ceratoides lanata* as it is associated with different shrub species.

INTRODUCTION

Most plants growing under natural conditions possess vesicular-arbuscular mycorrhizal (VAM) infection. In broad terms, mycorrhizae function as a mutualistic, symbiotic biotrophy between a fungus and a plant host. In fact, as cited by Reeves et al. (1979), the interdependence of the plant-fungus relationship has been described as "the ultimate in reciprocal parasitism." VAM is essential if desert plants are to survive and thrive in their environment of nutrient deficiencies and low precipitation. Desert soils are generally characterized as low in potassium, phosphate and nitrogen, as well as being extremely saline and alkaline. The growth advantages attributed to VAM of desert plants are believed to be associated with an increase in the nutritional status of the plant brought about by increased phosphorus uptake and water transport.

It has been shown in revegetation practices in the semi-arid West (Reeves et al. 1979) that mycorrhizal fungi are absolutely necessary for most plants in native environments and that a disproportionate number of species that are efficient colonizers of disturbed habitats are in traditionally nonmycorrhizal families. The results of their research provide data which support the hypothesis that nonmycorrhizal plants are effective colonizers of disturbed habitats and that the lack of mycorrhizal fungi exerts profound influences on species composition. Natural revegetation of disturbed surface soils in the semi-arid West is a slow process and the greater the severity of the disturbance, the slower the rate of recovery. Recovery of an ecosystem in part is dependent on either the rate of invasion of the site by propagules of mycorrhizal fungi which are viable or roots having or tolerating mycorrhizal fungi. The non-mycorrhizal species may hinder successional stages in the ecosystem recovery because they do not provide an inoculum source for subsequent species which requires mycorrhizal association for survival. Reeves et al. (1979) suggest that successful reclamation will depend on developing a

protocol to select and/or maintain the essential mycorrhizal fungi in disturbed habitats or development of methods to reinoculate these fungi in habitats where they are absent.

In order to qualify a plant root as infected with VAM, particular structures must be present: vesicles and hyphae, arbuscules and hyphae, pelotons and hyphae, or any combination of the three situations. Vesicles and arbuscules are by far the most prominent diagnostic features. The hyphae are normally non-septate and penetrate the epidermal cells of young roots behind the meristematic region. Hyphal growth may be entirely intracellular or primarily intercellular, depending on the host species (Gerdemann 1968).

Shortly after infection the fungus forms arbuscules, which resemble haustoria, within cortical cells. These structures develop by repeated dichotomous branching from a coarse trunk hypha. This entire complex forms a "little tree" that may nearly fill the lumen of the cell. Well defined arbuscules are very rare due to the extremely small (less than 1 in diameter) branches that are difficult to resolve with a microscope.

Vesicles are usually terminal ovate to sperhical sac-like swellings at the tip or in the middle of the distributive hypha. They can be thin or thick walled depending on age, with the latter becoming vacuolated and oil containing (Mosse 1963, Gerdemann 1968).

Investigations of the arid and semi-arid plant communities of Wyoming (Miller 1979), Colorado (Reeves et al. 1979) and Idaho (Wicklow-Howard 1982, 1983) have found that in natural, undisturbed communities the plants are normally mycorrhizal. When these communities are disturbed, nonmycorrhizal plant species predominate.

A previous investigation by the author (1982-1983) determined species of VA mycorrhizal plants at a site within the Cascade Resource Area of southern Idaho. Specifically, the study compared the incidence of VA mycorrhizal plants in an undisturbed sagebrush community with the incidence of VA mycorrhizal plants in a disturbed area adjacent to the undisturbed site. Approximately 25 species of plants were collected from the adjacent sites and about 75% of these plants had VA mycorrhizae. It was noted that the quantity of infection varies among plant species and also with a particular species between seasons.

The present investigation was carried out at the Birds of Prey Natural Area (BPNA), which is approximately 40 km south of Boise. The roots of 8 native Idaho shrubs were assayed seasonally for the presence or absence of vesicular-arbuscular mycorrhizae. In conjunction with the Bureau of Land Management 6 different sites were chosen, each with a different representative desert shrub composition.

A more comprehensive study of one shrub, Ceratoides lanata (winterfat) was conducted. Although members of the Chenopodiaceae are reportedly usually non-mycorrhizal, C. lanata appears to be an exception in certain semi-arid soils. Several collections of the roots of C. lanata were made, with the emphasis on its shrub associates. The associated species can greatly influence a plant's ability to form a mycorrhiza.

A combination of intractable factors (fossil fuel development, mining, arid land farming) presents the potential of severely disturbing the fragile desert ecosystem of Idaho. This necessitates the development of the best methods for re-establishing diverse, stable, and functional plant communities on disturbed land. These communities should be established with a minimum of investment of scarce resources, e.g., fertilizers, water, fossil fuels, and manpower. The establishment of functional communities presumes a knowledge of both the important macro- and micro-components of the system, i.e., both the above- and below-ground elements constituting the system. Vesicular-arbuscular mycorrhizae are among the ubiquitous components in below-ground ecosystems. The fungal symbionts appear to be essential in most ecosystems; these fungi, therefore, must be studied to understand ecosystem change and the potential of rehabilitating stable ecosystems in semi-arid Idaho.

METHODS

Description of study sites

Six study areas were chosen within the BPNA. Each site was selected based on its shrub species composition. Sites 1 and 2 are located off of Swan Falls Road. Sites 3-6 are found north and east of Swan Falls Road, off of Moore Road.

Method for assaying roots for mycorrhizae

Root samples are fixed in FAA preservative and are then cleared and stained following procedures of Phillips and Hayman (1970). Two separate techniques were followed. The first and more general technique used on non-pigmented roots involves clearing the roots in 10% KOH at 90°C for approximately 1 hour, rinsing in water, acidifying in dilute HCl and following with a staining procedure in 0.05% Trypan blue in lactophenol for approximately 5 min, and rinsing in clear lactophenol. The roots were then mounted on slides in clear lactophenol and observed. The second, and more specific, technique for the older, pigmented roots involved similar steps. The original clearing step in KOH was lengthened to 1 1/2 - 2 hours, and was followed by a wash in fresh KOH. This technique then included a bleaching step with an alkaline solution of hydrogen peroxide at 20°C for 10 min to 1 hour. The roots were then rinsed in water, acidified and stained as with the previous technique.

Once the staining and slide mounting was completed, the roots were observed with a dissecting microscope and fiber-optics illuminator, and they were also viewed with light microscopes. The dissecting scope proved quite useful in determination of mycorrhizal infection and the light microscopes aided in determination of structures and quantification of infection.

The quantification was done by placing a slide of cleared and stained roots under the microscope and moving it until mycorrhiza were located (vesicles + hyphae). Using a 100 unit grid, a ratio of the number of units containing a mycorrhizal structure against the number of total units the root covers was obtained. This constituted the first arbitrary count

taken. From this point, the slide was moved to the left and then again to the right to acquire 2 more counts. The percentages for each count were figured and then averaged to quantify the amount of mycorrhiza present.

RESULTS AND DISCUSSION

Table 1 reflects the percentage of mycorrhizae present in the shrubs species sampled in the semi-arid desert communities. This quantification allows the comparison of the amount of mycorrhiza present with regard to changes in season and vegetation.

The results obtained during the 1-year study show a general trend of greater quantities of mycorrhizae in the spring, when precipitation is also highest. Concurrent is the more active growth of the young, small feeder roots which contain the mycorrhizal structures at this time of year. *Artemesia tridentata* and *Gutierrezia sarothrae* are most notable in this respect. All species were mycorrhizal positive for at least one of the seasonal collections. Only *Tetradymia glabrata* was mycorrhizal positive during all seasons. *Ceratoides lanata* was non-mycorrhizal at all seasons at site #6. However, where it grew with more diverse shrub species (site #1) it was mycorrhizal at all seasons. The quantity of infection was only taken at 1 September 1983; however, positive identification of mycorrhizal structures was made on all collecting dates (see Table 2).

C. lanata was collected during the spring season from sites where it consistently demonstrated mycorrhizal infection. Sites #1 and #2, on the north and south sides respectively of Swan Falls Road, were used. Collections of *C. lanata* roots were made as it grew adjacent to other shrub species. At site #2, *Bromus tectorum* (cheatgrass) was always growing in the immediate area, as well as the associated shrub. The results of these experiments are presented in Table 2.

Sites #1 and #2 are described by Bureau of Land Management as atypical habitat for *C. lanata*, whereas site #6 is described as typical habitat. Comparison of the mycorrhizal data from these 3 sites clearly shows that the plant is more likely to form mycorrhizal associations in atypical habitats, with no preference for shrub associate. Williams and Aldon (1976) similarly reported on mycorrhizal positive species of Chenopodiaceae in certain semi-arid desert areas. This information is now allowing us to coordinate some efforts to aid in the re-establishment of *C. lanata* following disturbance of areas within the Birds of Prey Natural Area.

Table 1. Percent infection

	9-1-83	9-22-83	3-4-84	4-27-84	8-16-84
Site #1					
Ceratoides lanata (winterfat)	9.6	-	-	-	-
Artemisia tridentata (big sage)	1.6	0	16.0	12.0	18.8
Atriplex spinosa (spiny hopsage)	72.6	-	-	-	-
Artemisia spinescens (bud sage)	12.3	17.7	12.3	0	5.8
Site #2					
Tetradymia glabrata (littleleaf horsebrush)	10.7	57.3	6.7	18.7	6.7
Gutierrezia sarothrae (broomshrub)	0	38.0	29.3	12.7	57.7
Site #3					
Atriplex nutallii (Nutall saltbrush)	0	4.0	0	2.3	0
Site #4					
Artemisia spinescens (bud sage)	0	0	0	36.0	0
Atriplex confertifolia (shadscale)	14.7	0	2.3	11.7	1.1
Site #5					
Atriplex spinosa (spiny hopsage)	0	0	4.7	0	0
Site #6					
Ceratoides lanata (winterfat)	0	0	0	0	0

Table 2. Occurrence of mycorrhizae in the roots of Ceratoides lanata (+ or -)

	Dates 2/18/84	3/18/84	4/27/84
Associated Shrubs Species for Site #1			
Artemesia tridentata	+	+	+
Bromus tectorum	+	-	0
Atriplex nutallii	0*	+	0
Atriplex spinosa	0	0	+
Artemisia spinescens	0	0	+
Associated Shrub Species for Site #2			
Tetradymia glabrata	+	+	+
Gutierrezia sarothrae	+	+	+
Bromus tectorum	0	+	0
Artemesia tridentata	+	+	0
Artemesia spinescens	0	+	+
Tetradymia spinosa	0	+	+

* 0 No collection made.

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TITLE: Photographic Guide for Aging Nestling Ferruginous Hawks.

INVESTIGATOR: Marc Q. Moritsch, Boise, Idaho.

OBJECTIVES:

1. To develop a photographic aging key for nestling ferruginous hawks that will facilitate age estimation from a distance.

METHODS

During the 1984 nesting season, I photographed 2 young from a ferruginous hawk (Buteo regalis) nest. Approximate hatch date, to within 3 days, was determined by observing behavior of the adults and by visually inspecting the nest without entering during incubation. The nest was visited at 4-day intervals from the time the birds were 1 week of age until fledging. Chicks were removed from the nest at each visit, photographed, and returned to the nest. The nest was not entered before the chicks were 1 week old to reduce the chance of early nestling mortality. A plastic colored leg band was placed on each bird for identification. Photographs of the head, wing, and dorsum were taken with black and white and color film to allow identification of important characteristics. Where possible, photographs of the body include a scale or 10 cm grid.

RESULTS

It was possible to assign a unique series of characteristics to each age class. The number and combinations of useful characteristics increased with the age of the young.

Nestlings were downy until about 19 days of age. Body size and the stages of growth of the down were used to discriminate among the first 3 age classes (7, 11, and 15 days). At approximately 19 days of age feathers begin to show on the wings. The progression of development of wing, tail, scapular, and head feathers allowed distinctions to be made between later age classes. Comparisons among ages were easier following the appearance of juvenile feathers.

A BLM publication with photographs at 4-day intervals is expected to be printed in late 1985.

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